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PROGRAM manager

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ORGANIZATION OF JOINT CHIEFS OF STAFF AND SYSTEMS ACQUISITION: WHAT NOW/WHAT NEXT

Lieutenant Colonel Christopher A. Waln, USAF

Official Department of Defense photograph by Russ Roederer

An informal photograph of the Joint Chiefs of Staff. Left to right: General Alfred M. Gray, USMC; Admiral Carlisle A.H. Trost, USN; General Larry D. Welch, USAF; General Carl Edward Vuono, USA; Admiral William J. Crowe, Jr., USN, chairman; and General Robert T. Herres, USAF.

Defense acquisition process reform is a cottage industry in Washington, D.C., and 1986 was a banner year. Two events occurred which have changed the manner in which the defense acquisition bureaucracy functions—passage of the Defense Reorganization Act of 1986 and issuance of National Security Decision Directive (NSDD) 219.

These two events profoundly affected the Office of the Secretary of Defense (OSD), the Services, and the Organization of the Joint Chiefs of Staff (OJCS). This article defines the role the OJCS now plays and can be expected to play in the acquisition process and summarizes the potential impact on the program manager.

The OJCS was reorganized in 1986, and so terms of reference should be redefined even for those who have served there. The OJCS consists of the Chairman, Joint Chiefs of Staff (CJCS), the Vice Chairman, Joint Chiefs of Staff (VCJCS), and their personal staffs; the Joint Chiefs of Staff (JCS); the Joint Staff, and the individual agencies and boards reporting thereto. The Joint Staff now supports the CJCS in his role as the independent military advisor to the Secretary of Defense (SECDEF), the National Security Council, and President.

Vice Chairman, Joint Chiefs of Staff, is a new position created by the Reorganization Act with responsibilities defined by the CJCS and approved by the SECDEF. The VCJCS is the second-ranking military member of the Department of Defense and, by CJCS option, the focal point for OJCS involvement in systems acquisition.

In general, the VCJCS is responsible for seeing that CJCS goals—improving the way joint system requirements are identified, justified, analyzed, and satisfied and improving the way joint programs are managed—are achieved. During the long-term, the VCJCS will be the thread of continuity from CINC requirements to Service Program Objective Memorandums.

These goals are not new. In 1984, the Defense Science Board identified the need for a senior group to look after the requirements for, and management of, joint programs. Shortly thereafter, the JCS chartered the Joint Requirements and Management Board (JRMB) which did yeoman service during its first two years of operation. The original JRMB consisted of the Vice Chiefs of the Army and Air Force, The Vice Chief of Naval Operations the Assistant Commandant of the Marine Corps, and the Director, Joint Staff. Chairmanship was rotated annually among Service members.

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More than $4.5 billion in cost avoidance were documented as a result of JRMB efforts to identify opportunities for jointness in systems acquisition.

Pragmatically, JRMB efforts focused more on the reduction of duplication of effort in acquisition programs underway than on melding individual Service requirements into joint ones. Whatever its focus, the JRMB was a quiet, insistent, and effective force for giving the taxpayers more for their dollars; so effective, in fact, that the Packard Commission seized upon the JRMB name to replace the name (and to some extent, the function) of the Defense Systems Acquisition Review Council (DSARC). Accordingly, in June 1986, the original JRMB was renamed the Joint Requirements Oversight Council (JROC); its charter was not changed at this time.

Before 1984, the OJCS usually provided a senior representative to DSARC deliberations. Participation in the acquisition decision process was largely *ad hoc*, however, because there was no bureaucratic infrastructure within the Joint Staff to support any greater level of involvement. Such involvement was not envisioned when OJCS was created and staffed. This has given rise to a definitely outdated and unnecessarily broad criticism within the acquisition bureaucracy that "the JCS never met a requirement it didn't like."

This situation was in remedy during the same period as the early JROC activity. The Strategic Plans and Resource Analysis Agency (SPRAA), created at the behest of the Congress, gave the CJCS something of a program analysis and evaluation capability. The SPRAA was staffed with officers who understood both the acquisition process and the Programming, Planning, and Budgeting System (PPBS). The OJCS attendees at DSARC meetings began to arrive more fully prepared to deal with the issues, but a continuous thread to OJCS involvement in the process was absent.

When the first VCJCS, General Robert T. Herres of the U. S. Air Force arrived, many changes were imminent. The NSDD 219, implementer for the Packard Commission recommendations, had just been received for action and the Joint Staff had been restructured in anticipation of the Chairman's changing role. Mr. Richard Godwin, had just assumed the newly created position of Under Secretary of Defense for Acquisition (USD(A)).

> The DODD 5000.49 created the Defense Acquisition Board and ten committees were created to replace the 126 boards and councils that had carved out their own niches in the bureaucratic cliff.

Considerable activity ensued in the weeks and months following their arrivals. The DOD Directive 5000.1 and DODI 5000.2 were rewritten and staffed. The DODD 5000.49 created the Defense Acquisition Board (DAB), (a successor to the JRMB, aka DSARC), and ten DAB committees were created to replace the 126 boards and councils that had carved out their own niches in the bureaucratic cliff.

With respect to acquisition, the VCJCS was specifically given responsibility for: (1) bringing a strategic viewpoint to acquisition decision-making, (2) working for reduced duplication of capabilities and increased interoperability based on operational lessons learned, (3) chairing the JROC, (4) vice chairing the DAB, (5) representing the OJCS on the Nuclear Weapons Council (6) acting as CJCS spokesman on PPBS matters and as his representative to the Defense Resources Board (DRB); and, (7) acting as CINC representative on acquisition and requirements matters.

Strategic Viewpoint

What we acquire to equip the components must be consistent with who, where, what, when, and how we plan to use our military forces to achieve national strategic goals. This seems to be a first principle of defense acquisition, but there has been a growing feeling that our arsenal was in charge of our strategy.

The VCJCS has been charged with ensuring that the horse is, in fact, in front of the cart. This is especially important as we deal with the concept of fiscally constrained strategies. We cannot *afford* to be spending scarce resources on development programs which may do more to reinforce the institutional identity of the developer than contribute to the national defense.

Reduced Duplication and Increased Interoperability

Frankly, jointness is tough. It's tough on the battlefield, and it's tough in the program office. But just as frankly, there is only one war—no land war, no air war, no sea war—just one war. Every unnecessarily duplicated capability reduces the resources available to deal with other problems. Every system which is insufficiently interoperable is a boon to the

DISCLAIMER: This article represents the views of the author and does not necessarily reflect the official views of the Organization of the Joint Chiefs of Staff or the Department of Defense. The article is based on the author's presentations to the DSMC Executive Refresher and Executive Management Courses, and has been reviewed by the appropriate Joint Staff offices.

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bad guys, and a bull's-eye on our own instep. The Joint Staff will be aggressively supporting the Vice Chairman's efforts to make sure that these forms of jointness are achieved. An entire Joint Staff Directorate, the Director for Operational Plans and Interoperability, J-7, has been established to seek after, define and monitor the implementation of means to improve our combatant forces interoperability. The J-7 also provides staff support for the JROC. The Director for Command, Control, and Communications Systems, J-6, has been the focal point for interoperability for C3 systems and will continue to be.

Joint Requirements Oversight Council

As JROC Chairman, the VCJCS has had the Council rechartered to move its deliberations further "upstream" toward Milestone "0" to impact concepts as they develop rather than merely adjust programs as they are executed. Intuitively, it is better to have jointness considered early and applied prudently than it is to have it forced into a program after it has been structured. Two mechanisms are necessary to make the JROC effective in this role. One deals with Service development activities and the other with CINC capability requirements.

The annual Joint Potential Review and Designation Process is the mechanism dealing with Service development activities and produces the Joint Potential Designation List (JPDL). The intent of the process is to stimulate communication among the Services. All new Service and specified/unified command requirements documents, all research and development (R&D) programs approved for initiation and included in the Service Program Objective Memorandums, and all programs facing a Milestone I or II review in the next fiscal year are subject to review. All four Services must review, comment on, and assign Joint Potential Designators (JPD) to all candidate programs. The JPDs are required for all programs from acquisition category I through IV and are as follows:

—*Joint*, a potential for joint R&D program management and/or joint procurement exists.

—*Interoperating*, joint program management is inappropriate, but a potential for joint operation or joint system interface exists.

—*Independent*, no potential for other Service use or joint systems development.

The mechanism for dealing with CINC capability requirements is under development. It has much in common with the U.S. Army Concept Based Requirements System. The intent is to provide a method for developing conceptual approaches to solving CINC problems before component responsibilities are defined rather than having component involvement dictate the concept.

> We cannot *afford* to be spending scarce resources on development programs which may do more to reinforce the institutional identity of the developer than contribute to the national defense.

Both of these mechanisms will provide information central to DAB deliberations, and the Vice Chairman, JCS, is uniquely positioned to facilitate JROC-DAB communication and interaction. The ultimate goal is for the Joint Staff to have a well-defined position on the requirements for, and relative merits of, every DAB level program.

Defense Acquisition Board

With the VCJCS, as the DAB Vice Chairman, articulating Joint Staff positions which balance "jointness" and marginal return against prudent duplication of capability, the DAB can properly focus on *how* we buy *what* we buy; there are other forums for deciding what we buy. This means that the Joint Staff will be focused on keeping non-military influences from improperly changing the goals of a development program from what was intended when the requirement was validated.

The OJCS is not there to side with OSD against a Service, nor with a Service against OSD. The OJCS can be expected to take an independent position on each program, and that position will be rooted in linking strategy to plans, plans to requirements, and requirements to programs.

This means that the Joint Staff will participate fully in DAB Committee activities. The current ten committees were created to replace an anarchic approach to program oversight. Each committee has a Joint Staff Flag or General Officer member. Because the Joint Staff has limited acquisition professional resources these committee responsibilities have been "matrixed out."

(It is useful to remember when dealing with the 1,400 member Joint Staff that fewer than 140 have an occasional contact with acquisition issues, some 14 deal with acquisition daily, and 6 or so are acquisition management professionals.)

The major workload in support of DAB activities is handled by the Director for Force Structure, Resource, and Assessment Directorate, J-8, and the J-7. The J-7 oversees programs up to the draft Systems Concept Paper, and J-8 takes over from there through system retirement. The J-7 is responsible for seeing that the tie between plans and requirements is bound tight-

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ly, and the J-8 makes sure that the requirement is adhered to as the program proceeds. Some of the other Joint Staff Directors have similar responsibilities for certain classes of systems, such as Chemical Weapons and Nuclear Warheads (J-5).

The VCJCS role in the Nuclear Weapons Council (NWC) is similar to his role in the DAB, but his support for NWC activities comes almost exclusively from the Director for Strategic Plans and Policy, J-5.

Planning, Programming, and Budgeting

Once the DAB has determined that a given program's risks and acquisition strategy are consistent with program goals, the Defense Resources Board (DRB) determines whether, and at what level, the program will be funded. Though not often thought of in these terms, it is actually the DRB which provides Milestone "0" approval, not the DAB. As the CJCS representative to the DRB, the Vice Chairman will be working to ensure that DRB decisions underwrite stable programs, and that adjustments to existing programs do not balance the books at the expense of our strategic goals.

To make sure that he is in a position to do this effectively, the VCJCS is directing the Joint Staff evolution of an improved capability to conduct cost-trade analysis in support of developing fiscally constrained strategies.

CINC Spokesman on Acquisition And Requirements

The VCJCS will be sponsoring CINC requirements for consideration/validation when normal processes aren't appropriate or aren't equal to the task. As noted, most of this function will be assumed by the JROC but the *final* responsibility will rest with the Vice Chairman.

This means the VCJCS will direct/request Joint Staff/Service assistance to CINCs in developing Mission Need Statements and presenting Mission Area Analysis concerns. Ultimately, however, the VCJCS must balance CINC theater needs against the tendency to proliferate theater specific weapon systems.

Program Manager

The OJCS primary concern is the growing time required to move from promising technologies to deployed systems. From our perspective, program instability is key; it begins when requirements are defined poorly or become moving targets as the threat changes over long development periods. It is aggravated by a decision process which allows bureaucratic "gate-keepers" to delay programs for narrow parochial concerns. Finally, our budget process can leave even our best program managers focusing their skills on reducing budget uncertainty through program advocacy rather than reducing cost, schedule, and performance risk through sound program management.

The Defense Reorganization Act and NSDD 219 have provided the OJCS with the means to help reduce these sources of instability so that program managers can concentrate on the internal elements of their programs a little more and the externals a little less. During the coming years, program managers can expect to see more sister-Service uniforms in the meeting room, more joint funding initiatives, and less tolerance for the discovery of "disjointed efforts."

Lieutenant Colonel Waln is a Weapon Systems Program Evaluator for the Joint Staff. As such, he prepares Chairman and Vice Chairman, Joint Chiefs of Staff, to participate in SECDEF Performance Reviews, Defense Resources Board, Defense Acquisition Board, and Joint Requirements Oversight Council activities on USAF major system programs. He is the Joint Staff acquisition policy analyst.

GANTT MEDAL IS AWARDED

William S. Lee III has received the Henry Lawrence Gantt Medal from the American Society of Mechanical Engineers and the American Management Association. The medal is awarded annually for distinguished achievement in management as a service to the community. It was established in 1929 and memorializes Henry Lawrence Gantt, engineering manager, industrial leader, and humanitarian.

Mr. Lee, chairman and chief executive officer of Duke Power Company, headquartered in Charlotte, N.C., was recognized before 1,500 in Chicago "for the forward looking policies that have made his organization a leader in providing opportunities for minorities; for outstanding leadership examples in the development of safe, dependable power; for his continuing efforts to protect both the environment and the communities in which his organization operates; for his unflagging efforts to aid education through organizing scholarship programs within his organization and support councils to help meeting the needs of public schools, as well as his own personal efforts to aid students; for his overall management skills which have made his organization a leader in the field."

The American Society of Mechanical Engineers members on the Gantt Medal Board include David D. Acker of DSMC, Frank S. Locke, Nathan H. Hurt, Jr., William K. McAleer, and Robert Simmons.

AFIT SEEKING FACULTY

The Air Force Institute of Technology (AFIT) teaches systems acquisition/management courses to Air Force and DOD personnel in programs leading to masters degrees and in-programs of continuing professional education. It is seeking well-qualified individuals interested in teaching in those programs. Expressions of interest should be addressed to: AFIT/LS (Dr. W. Mauer), Wright-Patterson AFB, Ohio 45433-6583. Questions should be addressed to Professor William Dean, (513) 255-3355 or AV 785-3355.

PMC 88-1 GRADUATES HEAR DR. COSTELLO

The Honorable Robert B. Costello, Under Secretary of Defense (Acquisition), in his remarks to the Program Management Course 88-1 graduating class at the Defense Systems Management College in May, said "this graduation is significant because it is the first of three DSMC will have during 1988 under the new accelerated PMC structure, replacing the former throughput of two classes annually.

"I recognize the tremendous effort all of you on the faculty and staff have put into making this new process work. I know the overlap in classes tended to be confusing at first, but it all came together.

"Things have changed at DSMC, most prominently the mission. Now, DSMC is responsible for all *acquisition education*, rather than *just program management* education as before....To each of you here today, continue to work not only for the good of the college, but for improving everything we do in defense acquisition."

Dr. Costello said graduates are military and civilian officials and are among tomorrow's top government and industry leaders. Each has been recognized as having high potential to be the best. "A lot is riding on your shoulders," he said, "and the directions and actions our country takes in the future will depend upon judgments and decisions you and counterparts will make. It is an awesome responsibility and must be handled judiciously. If there is one single point I wish to drive home today, it is that Department of Defense people must make changes in mindset, form and substance—the total picture—in order to improve the way we do business. What we in the Department of Defense have set out to change will be done gradually, not overnight, but it must be done.

"Changes must be initiated at the top, encouraged at the top, implemented at the top, and led at the top. Top management must be committed to change, and then follow through to accomplishment.

Meet Challenges

"Whether you will be in management or staff positions, you must support efforts of those above you to make the necessary changes, and fully execute them down the line. As you advance in your careers, these and other challenges await you. Meet them head-on.

"Do not be satisfied with, or fearful of, established institutions as monolithic intimidators. Believe that the Department of Defense way of doing business can be done better. Have courage of your conviction to put into practice only that which is best for our fighting forces, and for national security. Discard the superfluous.

Financial Constrictions

"Your leadership ability will be tested severely in coming years. Tight financial constrictions...will be with us for the forseeable future....Many of you will work on the program objectives memorandum and budget at the Pentagon and at headquarter levels ....You will wrestle with probable budget cuts, program delays, stretch-outs and perturbations. Your managerial skill to get the most for available dollars will bear on your job performance but, most importantly, will greatly affect the end product—whether it be weapon platforms, strategic systems, communications, size of forces, or numbers of people.

"The management and leadership principles you have honed at the Defense Systems Management College will prepare you well for years to come, and help you make it through exciting, turbulent and, occasionally, stressful times."

Dr. Costello said that it stands to reason that management and leadership principles improving the acquisition process apply across-the-board, in every facet of government. He told graduates they will inherit many decisions of the past; some will bind, others will not. "Your contribution to government, and the payoff of your DSMC education will be to use proper initiative, common sense, and judgment to make the ultimate hard decisions—and make them right," he said.

Dr. Costello concluded his remarks by saying that "it takes leadership to convince people and established institutional processes that changes will make everyone's job easier, and provide the best and least expensive systems for the field.

These are excerpts from Dr. Costello's graduation address. His ten agenda items for improving defense acquisition were detailed in the May-June 1988 issue of **Program Manager.**

NEW COMMANDANT

Official Photograph by James Pleasants

Major General Lynn H. Stevens, USA, tenth Commandant of the Defense Systems Management College.

Official Photograph by Janet R. M. Fitzgerald

The "flag is passed" at the Change of Command Ceremony April 29 at the Defense Systems Management College, Ft. Belvoir, Va.

Major General Lynn H. Stevens, USA, was Deputy Chief of Staff for Development, Engineering and Acquisition, Army Materiel Command, before becoming DSMC's tenth Commandant April 29. He has held important command and staff positions including Director of Materiel Plans and Programs in the Office of the Deputy Chief of Staff for Research, Development and Acquisition, U.S. Army; Project Manager, HAWK Missile System, Redstone Arsenal, Ala.; Project Manager, ROLAND II Missile Systems, Redstone Arsenal; and Commanding General, U.S. Army Materiel Development and Readiness Command, Europe.

In Vietnam, General Stevens was Executive Officer, later Materiel Officer, 191st Ordnance Battalion, 500th Transportation Group, and Operations Officer (S-3), 500th Transportation Group, U.S. Army Cam Ranh Bay Support Command.

Other assignments in his 30-year military career include Assistant for SAFEGUARD and Selected Acquisition Reports, Office of the Assistant Secretary of the Army (Installations and Logistics); Commander, 197th Ordnance Battalion, 59th Ordnance Group, USA Europe; Chief, Nuclear Weapons Staff, Office of the Deputy Chief of Staff for Logistics, USA Europe and Seventh Army; and Logistics Staff Officer in the Maintenance, Policy, and Programs Division, Supply and Maintenance Directorate, Office of the Deputy Chief of Staff for Logistics, USA Washington.

General Stevens returned overseas as Chief, Munitions and Missiles Division, Office of the Deputy Chief of Staff for Logistics, USA Europe and Seventh Army, and later became Commander, 59th Ordnance Brigade, USA Europe.

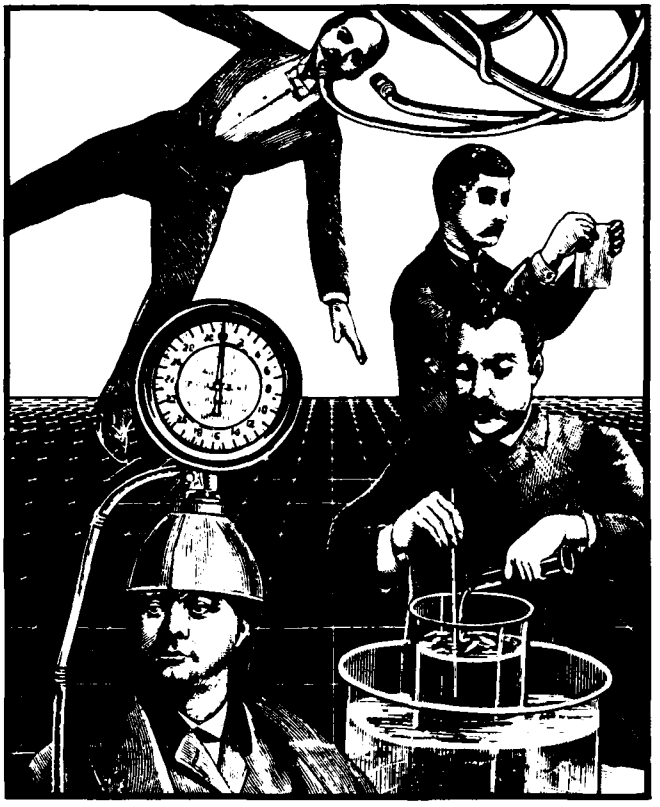
Official Photograph by James Pleasants

General Stevens (left) cuts cake with help of The Honorable Robert B. Costello, Under Secretary of Defense for Acquisition, and Brigadier General Charles P. Cabell, Jr., USAF, retiring Commandant.

DISPELLING MYTHS OF TEST AND EVALUATION

Dr. H. Steven Kimmel

Assistant Deputy Director
Defense Research and Engineering
(Test and Evaluation)



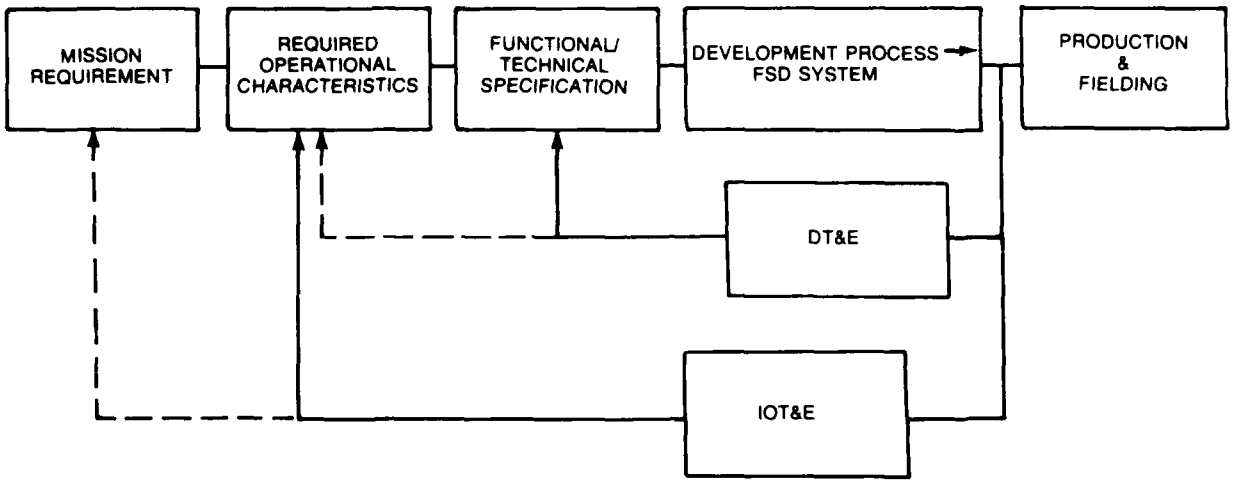
Test and Evaluation is recognized as a key element of the weapon system process. By long-standing practice and directive, weapon system test and evaluation is divided into two principal categories—Development Test and Evaluation (DT&E) and Operational Test and Evaluation (OT&E). As defined by the governing directive (DoDD 5000.3, "Test and Evaluation"), DT&E is conducted throughout various phases of the acquisition process to ensure the acquisition and fielding of an effective and supportable system by assisting in the engineering design and development and verifying attainment of technical performance specifications, objectives and supportability. The OT&E is the field test, under realistic conditions and by typical users of the weapon system (or element thereof) to determine its suitability and effectiveness.

While DT&E emphasizes engineering design and technical performance, its ultimate goal, like that of OT&E, is to ensure the acquisition and fielding of weapon systems that are effective and supportable under combat conditions. One should not expect DT&E, by itself, to be sufficient to fully ensure effective, supportable combat operation. Key elements of realistic testing are reserved to OT&E; e.g., operation by typical military users in as realistic a representative field condition as possible against threat representative hostile forces. Nonetheless, it is clear that the utility of DT&E as an acquisition tool is increased when Development Test (DT) results can serve as a reliable predictor of Operational Test (OT) performance.

Figure 1 presents a simplified model of the weapon system acquisition process to assist in examining the relationship between DT&E and OT&E. The model suggests that test and evaluation is a continuum of activities interwoven with the acquisition process. In reality, the maturing DT&E and initial phases of OT&E (IOT&E) events do not fit into rigid or discrete compartments; both are involved with broad, system-level concerns. This relationship is a matter of ongoing interest and often the cause of confusion and misunderstanding. In addition, recent enactments by the Congress have drawn attention to the Office, Secretary of Defense (OSD) T&E communities' management, execution and actions. The result of this certainly needs to be well understood by those engaged in the acquisition of weapon systems. Accordingly, the reader is invited to take and evaluate the test on the next page.

The intent of this test is not to provide pass/fail criteria for the reader, but to clarify ongoing relationships between DT&E and OT&E communities. More precisely, the entire T&E community is being challenged to support the evolving acquisition community goals and objectives. Using viable test programs and the commitment to objective assessments are the essential means to achieve results recently expressed by the Army Chief of Staff General Carl E. Vuono:

FIGURE 1. MODEL OF WEAPON SYSTEM ACQUISITION PROCESS



Test and Evaluation is very important because putting less than adequate weaponry into the hands of our soldiers is a price that we all cannot afford.

Fifteen Questions

1. The OSD Test and Evaluation environment is divided and fragmented. T or F

2. Test and Evaluation assessments go unheeded. T or F

3. Weapon system acquisition time has increased due to the demands/requirements for more testing. T or F

4. Existing T&E policies of DOD and military departments are inconsistent in philosophy and approach. T or F

5. Development Test (DT) and Initial Operation Test (IOT) are incompatible in purpose. T or F

6. Test and Evaluation Master Plans (TEMPs) are needed solely to comply with DoD Directive 5000.3, "Test and Evaluation"; i.e., to fulfill a process requirement. T or F

7. Until recently, software T&E has placed emphasis more on "T" than "E" and has thus endorsed the *Design-Test-Redesign-Retest* philosophy of development. T or F

8. Live Fire Testing is solely an Army test program brought about by the Bradley Live Fire Test (LFT) effort. T or F

9. Non-development item (NDI) is an acquisition strategy that eliminates the requirement for Test and Evaluation master planning. T or F

10. A balanced structured system test plan treats hardware, software and the user as equals. T or F

11. Preplanned product improvements (P3I) or evolutionary acquisition (EA) strategies (yes, there is a difference) minimize the conflict between DT and OT. T or F

12. Concurrent acquisition strategies typically reduce schedule risk at the expense of informed decisions. T or F

13. Operational suitability and operational effectiveness are graduation characteristics validated as a consequence of OT. T or F

14. Nuclear hardness and survivability (NH&S) objectives are to be achieved in DT and confirmed in OT. T or F

15. Weapon system (platform) combat survivability is a function of susceptibility and vulnerability. T or F

Answers to Questions with Supporting Rationale

1. The OSD Test and Evaluation environment is divided and fragmented.

False. That is, while the OSD T&E function is fragmented organizationally, its purpose is not. Clearly, the Director of Operational Test and Evaluation (DOT&E) is responsible for

providing OT policy, while the Deputy Director of Defense Research and Engineering (Test and Evaluation), DDDRE(T&E), is responsible for DT policy generation. However, both entities agree that:

—"Test planning" must begin early

—Early test results are essential to support design to production decisions

—The DT objectives must posture a system OT

—The OT must be viewed as a graduation type of event rather than a final exam.

A single OSD organization would not alter this ideology. Two organizations permit focused attention upon a myriad of related matters such as test facilities (instrumentation and ranges), test targets, threat surrogates and simulators, live fire testing, joint tests, and foreign weapon evaluation. Most importantly, it allows independent, objective weapon systems assessments from a development perspective to ensure that engineering thresholds have been attained and from an operational perspective to verify the suitability and effectiveness is confirmed before proceeding beyond low-rate initial production.

2. Test and Evaluation assessments go unheeded.

False. The T&E assessments are an integral influence in the defense acquisition decision-making process. Routine vehicles such as weekly "quick look" T&E correspondence and more detailed status reports and memoranda are frequently generated to ensure the Secretary of Defense and Under Secretary of Defense (Acquisition) are appraised of acquisition T&E matters. Lastly, the T&E assessments provided to the Defense Acquisition Board often form the foundation of the resultant Acquisition Decision Memorandum that directs the Service Acquisition Executive during the forthcoming months of program execution.

3. Weapon system acquisition time has increased due to the demands/requirements for more testing.

False. During 1987, as a result of congressional interest, a thorough and comprehensive review of the weapon system acquisition process judged that a vigorous, well-planned T&E effort is time-efficient and a wise investment. The conclusion from the evaluation of testing time is that T&E is not a reasonable target for time reduction in pursuit of a speedier acquisition process, and that a cutback in T&E could actually lead to a longer and costlier acquisition process.

4. Existing T&E policies of DOD and military departments are inconsistent in philosophy and approach.

False. The DoDD 5000.3, "Test and Evaluation," sets forth the broad philosphical basis for T&E and identifies specific responsibilitites and methods for all T&E actions in the Department of Defense. It highlights the purpose of testing, the relationship between DT & OT as currently defined, specific military service responsibilities, and T&E planning and execution requirements.

The military services, in turn, have each prepared regulations that implement the guidance contained in DoDD 5000.3 for their respective organizations. In general, the military services are in concert with the fundamentals of the DOD T&E guidance, although there are differences in terminology and approach. For the most part, this is a consequence of the different weapon system classes and operating environments with which each military service must deal.

5. Development Test (DT) and Initial Operational Test (IOT) are incompatible in purpose.

False. The T&E is an integral part of the acquisition process, interacting with other program functions that support the development of a product design and helping to determine the operational effectiveness and suitability of a weapon system. Testing (development and operational) must begin early and be done continuously rather than viewing it as a "final exam." Accordingly, the relationship between DT and IOT is separate, yet complementary. For example, an early operational assessment is often based upon the DT data. In the end, they contribute to a healthy T&E environment which, in turn, helps the DOD in its decision process. The DT contributes to the design portion of the process, whereas OT establishes the information base for recommending when a program is ready to proceed past a low-rate initial production.

6. Test and Evaluation Master Plans (TEMPs) are needed solely to comply with DoDD 5000.3, "Test and Evaluation"; i.e., to fulfill a process requirement.

False. The purpose of a TEMP is to:

—Identify the scope of planned testing

—Delineate acceptable evaluation criteria

—Foster sound program management by which to execute a rational, logical course of action.

The concept of a TEMP is detailed in DoD Manual 5000.3-M-1, *Test and Evaluation Master Plan Guidelines*, and supports the premise that the document should be viewed as a tool to ensure program management success. The TEMP should serve as a roadmap rather than a detailed test plan. Accordingly, program officials should use it as a vehicle to confirm, via test results, the progress of a maturing set of events. This progress is examined continuously during the development period and is necessary to facilitate the certification that the developing system under test is ready for OT. Utilizing evolutionary thresholds that span the phases of advanced and engineering development right through the certification for OT readiness and leading to initial operational capability can become bona fide checkpoints to support acquisition management decisions.

Hence, the TEMP is and should be viewed as a living document, accommodating annual updates and revisions. Meanwhile, the TEMP must track with the approved requirements and Decision Coordination/System Papers to ensure that the objective system, once fully fielded, satisfies the military user's required operational needs (final set of evolutionary thresholds).

Accordingly, military service submitted TEMPs receive a thorough and comprehensive OSD-wide review to ensure that programmatic and tech-

nical viewpoints, concerns and details are adequately addressed.

7. Until recently, software T&E has placed its emphasis more on "T" than "E" and has endorsed the *Design-Test-Redesign-Retest* philosophy of development.

True. The design-test-redesign approach has been observed to be costly (see note below) and inefficient for hardware and software development efforts. Therefore, the soon-to-be published DoD Manual 5000.3-M-3 "Software Test and Evaluation Manual" will advocate the following:

1. DoD-STD-2167, "Defense Systems Software Development," which established a tri-service approach for designing and building in software quality vice testing in software quality. Quality is one measure of software maturity.

2. Development of mathematical means of determining software correctness analytically during design and prior to code development, leading the way to error reduced software being developed in a "clean-room" environment. This is still in its infancy.

3. Support the DOD implementation of Ada for use in all weapon systems. This approach fosters the early detection and prevention of requirement and design errors prior to software coding.

4. Improving management visibility, testing, and assessment tools which promote management attention, early detection, and correction of software problem areas.

NOTE: Evidence produced by software studies indicates that, on the average, approximately 40-60 percent of DOD software development dollars are spent on software test-related activities.

8. Live Fire Testing is solely an Army test program brought about by the Bradley Live Fire Test (LFT) effort.

False. Vulnerability of the Bradley Fighting Vehicle was initially quantified by the OSD sponsored, joint Live Fire Test effort. In FY 87, the Congress established a DOD-wide Live Fire Test mandate to be overseen by OSD and executed by each military service. The enabling legislation states that LFT shall be executed sufficiently early in the development phase of the system or program to allow any design deficiency demonstrated by the vulnerability testing to be corrected in the design of the system, munition or missile before proceeding beyond low-rate initial production.

The TEMP is the umbrella document to record the scope of a system, munition or missile's LFT. The supporting Detailed Live Fire Test and Evaluation Plan contains the subsystem and component or full-up testing needed to assess system vulnerability or lethality. Such a full-up test may be waived by the Secretary of Defense prior to *entering* Full-Scale Development and provided that the Secretary certifies to the Congress that LFT would be unreasonably expensive and impractical.

9. Non-development item (NDI) is an acquisition strategy that eliminates the requirement for Test and Evaluation master planning.

False. The use of NDI is based upon the results of a market surveillance and analysis performed early in the system life cycle. Typically, the analysis determines the feasibility of satisfying a military deficiency or need by utilizing commercial off-the-shelf products. These products may be used either directly, or ruggedized for military environments, or integrated into existing or evolving system design(s). In any case, the degree of testing will be commensurate with the degree of integration and/or modification required. It will be inversely proportional to the depth of contractor data appropriate for evaluating military operational suitability and effectiveness.

As described in the forthcoming DoD 5000.3-M-5, "Procedures Manual-Improving Test and Evaluation Effectiveness in Support of the Major Weapon Systems Decision Process," the testing of an NDI must not impede the objectives of streamlining the acquisition process. Rather, it must be accomplished in an orderly, objective fashion consistent with the approved TEMP.

10. A balanced structured system test plan treats hardware, software and the user as equals.

True. A balanced test plan is necessary to ensure that system and mission objectives will be supported by maturing hardware and software. The test plan must address hardware (including mission critical computer resources as well as front-end sensors), software (firmware as well as resident and data flow induced), user elements and the integration of all of these elements. System-level testing should be designed and conducted to demonstrate the contribution of hardware, software and people to the quantification of reliability, availability, and maintainability parameters.

11. Preplanned product improvements (P3I) or evolutionary acquisition (EA) strategies (yes, there is a difference) minimize the conflict between DT and OT.

True. The P3I and EA contain a modular building block concept to enable the integration of progressive hardware and software design enhancements capable of meeting futuristic mission objectives by the phasing-in of upgradable intrinsic elements.

The enhancements result in cost avoidance in such areas as obsolete system software, planned delivery of new technology and the tailoring of operational characteristics to increase the utility of available, employable technology.

Hence, at the system level, the adaptation of P3I or EA tends to minimize DT and OT conflicts by accommodating design changes during a spectrum of time as evidenced by specific development objectives and OT expectations. With a balanced test program consisting of integration, interoperability, and compatibility testing, the modular concept can provide the roadmap to reduce test and acquisition conflicts.

12. Concurrent acquisition strategies typically reduce schedule risk at the expense of informed decisions.

False. In the usual context, concurrency means either the simultaneous DT/OT or the more common interpre-

tation of simultaneous DT/OT and production.

With concurrent DT/OT the program office and contractor are faced with the dilemma of trying to collect developmental data as quickly as possible while providing and supporting a system for the independent operational tester to verify user requirements. What often happens is the curtailment or retarding of developmental data taking to ensure compliance with a particular operational performance threshold, thus impeding overall development and progress toward certification for dedicated system level OT. Some concurrency in DT/OT is beneficial but only to the extent that quick-look OT evaluations are used to assist the developer and help refine system specifications.

D· .rimental concurrency of DT/OT occurs, for example, when the program office/contractor team candidly admits their attention has been diverted from developmental to operational testing. Typically, this means that the preference to collect data (i.e., to fire several telemetry equipped missiles) followed by the opportunity to correct engineering deficiencies has been set aside in deference to the necessity to rehearse IOT&E to minimize the possibility of any embarrassing operational occurrences. Thus, the attainment and confirmation of development objectives as verified through flight test become mitigated.

13. Operational suitability and operational effectiveness are graduation characteristics validated as a consequence of OT.

True. The latter phase of OT (i.e., OTII), is the place to prove operational effectiveness. Whereas some of operational suitability can be assessed from the results of DT, DoD 5000.3 states that operational suitability under realistic conditions is to be validated during OT.

14. Nuclear hardness and survivability (NH&S) objectives are to be achieved in DT and confirmed in OT.

True. The DoDI 4245.4, "Acquisition of Nuclear-Survivable Systems," states that "NH&S objectives are (to be) achieved during DT and OT&E."

In addition, DoDD 5000.3, "Test and Evaluation," states that "DOT&E is responsible for (confirming), in coordination with the Assistant to the Secretary of Defense for Atomic Energy, ATSD(AE), that OT&E confirms NH&S as intended."

"DDDRE (T&E) is responsible for confirming, with advice from the ATSD(AE), that NH&S objectives are achieved during DT&E."

As we are aware, testing to confirm NH&S must depend upon a combination of tests, simulations and analysis. Like the non-nuclear survivability area, severity of the mission degradation will be extrapolated in terms of the ability of the threat operating environment to exceed the system design capabilities, thereby affecting system survivability. The degree to which the system survives will directly contribute to mission abort, mission degradation, nuisance or no response. In the end, the system's design (development objective) must be robust to lie somewhere between impervious to the expected threat (i.e., no vulnerability), to built-in recovery (observable degradation) and the acceptance of partial (but militarily acceptable) operational suitability and effectiveness.

15. Weapon system (platform) combat survivability is a function of susceptibility and vulnerability.

True. Survivability is "the capability of a system to avoid and/or withstand a man-made hostile environment" without suffering abortive impairment of its ability to accomplish its designated mission.

One element of survivability must be expressed in terms of the intrinsic system ability to use whatever possible natural phenomena, countermeasures or tactics to avoid weapons (ballistic projectiles, guided missiles, exploding warheads, and other elements that make up the hostile environment). That is, the measure can be expressed by P_h, the probability that the system may be hit by a damage-causing mechanism, and is referred to as the *susceptibility* of the system.

The inability of a system to withstand the damage caused by the hostile environment is referred to as the *vulnerability* of the system to the damage mechanisms. Vulnerability can be measured by $P_{k/h}$, the conditional probability that the system will be killed or degraded given a hit by a damage mechanism.

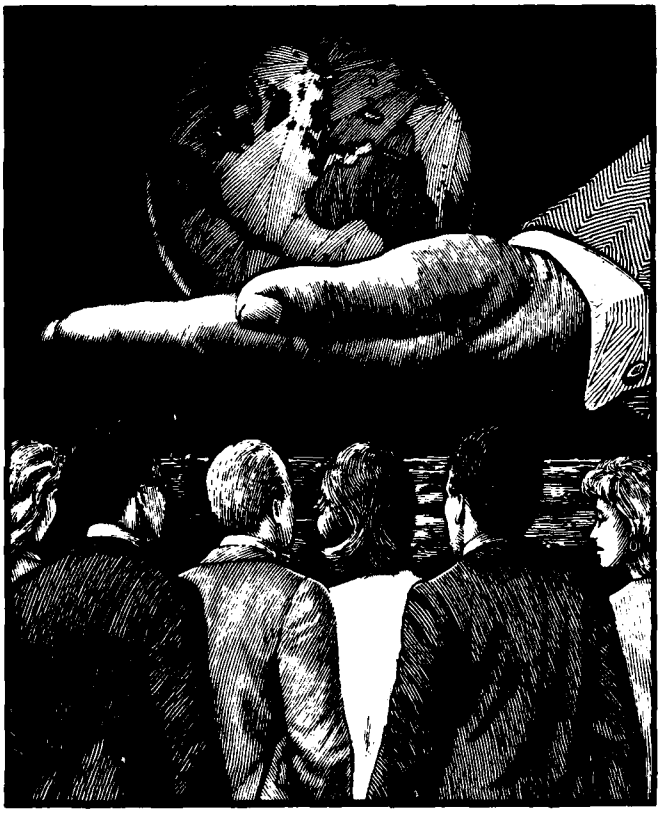
The extent that a system's effectiveness may be reduced by the hostile environment is measured by the probability the system is killed P_k or degraded P_d. The probability of kill of the system is the product of the probability of hit (the susceptibility), P_h, and the conditional probability of kill given a hit (the vulnerability), $P_{k/h}$, that is:

Probability of Kill = Susceptibility * Vulnerability $P_k = P_h * P_{k/h}$ is appropriate for conditions of permanent damage; i.e., high explosive induced, and Probability of Degradation = Susceptibility * Vulnerability $P_d = P_h * P_{d/h}$ is appropriate for conditions of temporary damage; i.e., electromagnetic induced.

Thus, the *survivability* of the system can be expressed as a capability to endure in a hostile environment as measured by the probability of survival P_s. Its relationship to P_k is given by $P_s = 1 - P_k$.

C/SCSC LESSONS LEARNED THEORETICAL FRAMEWORK

Dr. Anthony Webster



Program managers for the government, and defense contractors have come a long way since early implementation of the Arthur D. Little Cost/Schedule Control System Criteria (C/SCSC) in the early 1967-68 time frame. Currently, there is less apprehension of the criteria, and the cost to implement appears to be reasonable in most cases. Contractor and government personnel continue to learn more and better ways to use C/SCSC and analyze performance measurement data. Many observations have been made and many lessons have been learned.

In 1975, a C/SCSC Implementation—Lessons Learned—study was conducted by L. S. Morrella and J. B. Holeman as a project during the Defense Systems Management College PMC 75-1. That paper documented the "corporate memory" of C/SCSC experiences and lessons learned for the 7-year span, 1968-75.

My paper builds on earlier research, attemping to compare deficiencies and lessons learned identified in 1975 with current observations of deficiencies in the discipline (12 years later).

Lessons learned as observed in the 1975 study are provided in Table 1.

Other areas of co: cern were program instability, schedule variance expressed in dollars, accounting for material at point of usage, level of detail involved, cost associated with implementing and inflexible interpretation of criteria.

The Lessons Learned (Figure 3, pp. 20-22) reflects perspectives taken from seven vantage points as a/an:

—Contractor performance measurement instructor working with user population
—Observer of feedback from C/SCSC validation reports
—Participant in C/SCSC focal points and review director meetings
—Participant in NSIA Management Subcommittee meetings
—Consultant providing C/SCSC support to government agencies
—Member of the Performance Management Association
—Participating team member on demonstration and subsequent application reviews.

Background

Observation #1. A recent Air Force study reveals that of 86 reviews conducted from 1984-87, 70.5 percent were satisfactory, 11.4 percent marginal and 18.2 percent unsatisfactory. The deficiency distribution by criteria categories for those reviews are shown in Table 2.

TABLE 1. LESSONS LEARNED IN 1975 STUDY

C/SCSC	
SUBJECT	REMEDY
Retrofit applications (not cost effective, disruptive)	Retrofit applications should be avoided.
Premature demonstration reviews (not cost effective, disruptive)	Realistic schedules must be developed. Meaningful readiness assessments. Contractor should not drag out process.
Lack of program management office involvement	Encourage Department of Defense (DOD) program managers to have office well represented on the review team. (Big dividends in terms of understanding and visibility).
Lack of headquarters guidance	Provide adequate and standard guidance to all review team members. Make it the responsibility of the review director to implement a standard interpretation of the criteria and be well-trained in the C/SCSC discipline.
	The review director should be provided by the major military service headquarters.
Lack of plant representative involvement.	Enforce DOD requirements that contract administrators and auditors conduct continuing monitoring and surveillance of contracts. The Cost Accounting Standards (CAS) and Defense Contract Auditing Agency (DCAA) should be involved in demonstration reviews. The Memorandums of Agreement (MOAs) should be established.
Top management support	"Units do well those things the Boss checks." Top management on both sides must embrace and support the requirement.
Analysis and use of data	Help contractor and government analysts to have a better appreciation of data value and emphasize a greater understanding of data analysis, and utilization.
Estimates at Completion (EACs) review team members	Emphasize the need for meaningful and disciplined EACs. The EACs should be realistic and timely. Turnover must be minimized and adequately trained.

TABLE 2. CRITERIA CATEGORIES

NUMBER	C/SCSC CATEGORY	PERCENT
I	Organization	3
II	Planning and budgeting	48
III	Accounting	20
IV	Analysis	24
V	Revisions and access to data	5

TABLE 3. DEFICIENCIES

DEFICIENCY	FREQUENCY OF OCCURRENCE PERCENT
Estimate of cost at completion	61
Selection of earned value technique	50
Level of effort application	50
Subcontractor performance measurement	44
Baseline establishment and control	44
Variance analysis and reporting	44
System discipline	39
Material control	33
Validity of computer runs	33
Reconciliation of external reporting data with internal data	27

TABLE 4. PROBLEMS IMPLEMENTING C/SCSC

PROBLEM CATEGORY	REASONS
System problem	System not required for years (not updated)
	Deviations from validated system
	Poor internal audits
Implementation problem	Training schedule traceability
	Application of earned value techniques
	Quality of variance analysis
Government problem	Undefinitized contracts
	Unrealistic target cost
	Poor surveillance
	Program office allows non-compliance

Other areas of concern by the Air Force were excessive data reporting requirements, delayed reporting of material and subcontractor cost variances and qualifications of C/SCSC Review Team members and Teeth in C/SCSC (remedies) for non-compliance.

Observation #2. The Navy analyzed 18 Validation Review Reports of contracts totaling $1.8 billion and identified the 10 most frequently reported deficiencies that could affect validity of cost data. Table 3 shows the deficiencies and their frequency of occurrences observed during the 18 reviews.

Observation #3. In a recent presentation made by the Tri-Service Focal points, current problems implementing C/SCSC were identified and divided into three major categories—systems problems, implementation problems and government problems. Table 4 shows the information provided in that presentation.

Observation #4. In an interview with a C/SCSC management consultant who has supported the government, I asked him to provide a list of major deficiencies in implementing C/SCSC based on his company's experiences. Data provided are shown in Table 5.

Observation #5. Feedback from Contractor Performance Measurement Course students, C/SCSC Seminars I have attended for the last 5 years and speaking with major defense contractors provide a composite overview of perceived key problems in the implementation of C/SCSC.

They are:

—Interfacing with existing systems

—Establishing and maintaining WBS vs. cost accounts

—Developing code fields to integrate cost/schedules

—Establishing objective earned-value techniques

—Keeping the baseline up-to-date

—Reporting against unrealistic baselines

—Accounting for materials and multi-function equipment

—Handling subcontractors (especially in research and development)

—Using Management Reserve as a management tool.

TABLE 5. MAJOR DEFICIENCIES IN IMPLEMENTING C/SCSC

PROBLEM CATEGORY	REASONS
Planning	—Incorrect identification of cost accounts —Weak relationship between the Work Breakdown Structure (WBS) and statement of work —Inadequate development of the WBS —Poor definition of work —Inadequate integration of budget, schedule, and work authorization —Overallocation of budget —Forward planning at too high a level
Control	—Work status not based on work package progress —The Budgeted Cost for Work Performed (BCWP) technique not consistent with resource application —Performance measurement at incorrect level —Improper or late incorporation of changes —Invalid baseline maintenance system —Material costs not applied properly
Accounting system	—Accounting periods do not match customer or subcontractor accounting periods —The 12 vs. 13 accounting periods during the year —Reports prepared after accounting month closing —Inadequate follow-up to reduce errors —No recording of labor and material transfers between departments and projects
Data analysis	—Variance analysis system not maintained —Performance inadequately monitored —Corrective actions not followed up —Estimates at completion not updated
System maintenance	—System design too complex —Documentation not accurate —Training not done continuously

TABLE 6. OPPORTUNITIES FOR IMPROVEMENT

PROBLEM CATEGORY	REASONS
Baseline change	The DOD change order process does not permit work to start prior to receipt of authorization.
	Lack of timely accountability in Performance Measurement Baseline (PMB).
Review process	Lack of consistency in the criteria interpretation between review teams.
	Preconceived changes directed prior to the scheduled review.
C/SCSC application	Lack of flexibility in its implementation during the research and development phase.
Variance analysis	Formal documentation of analysis is time consuming.
	Some reporting is repetitious, extra paperwork.
	Thresholds are too low.
CPR reporting	The levels for reporting requirements are too low.
WBS	The MIL-STD 881-A should be a guide, not a mandate.

TABLE 7. MAJOR AREAS FOR IMPROVEMENT

PROBLEM CATEGORY	REASONS
C/SCSC review process	Team member qualifications (not well qualified).
	Turnover rate is high.
	Career path problems.
C/SCSC application interpretation	Lack of consistency in criteria.
	Time allowed for implementation.
	Lack of incentives for a contractor to work C/SCSC.
	Lack or understanding of C/SCSC capabilities and limitations by both government and industry.
Cost performance reports	Excess reporting.
	Timeliness of reports.
	Quality of variance analysis.

Observation #6. Table 6 identifies areas some Defense contractors believe presented the greatest opportunity for improvement in the implementation of C/SCSC.

Observation #7. The C/SCSC survey of Department of Defense and contractor managers Phase II was also a source considered for background information. Phase II of referenced survey identified problems, whose resolution could lead to improvements in the implementation of C/SCSC. The major areas for improvement identified in this survey are provided in Table 7.

APPROACH

Analysis of Data

The observations give background information to show a representation of major deficiencies/problems associated with implementing C/SCSC and Lessons Learned. They represent a cross-section of government and industry program management sources throughout the country. This data covers from 1968 through 1987. The referenced data set includes: The C/SCSC Study, "Lessons Learned," 1968-75; Air Force C/SCSC Review Results, 1987; Navy C/SCSC Review, 1986; C/SCSC Tri-Service Presentation, 1987; C/SCSC Management Consultant Interview, 1987; Feedback from CPMC student population and C/SCSC seminars, 1983-87; Consortium of Defense Contractors: C/SCSC Response, 1987; and Arthur D. Little C/SCSC Survey, 1986.

The deficiencies identified through the data set were stratified into 27 categories and put into a matrix. See Figure 1, C/SCSC Implementation Deficiency Matrix, to determine the frequency of occurrence among the eight sources used in the data set. The frequency distribution is shown in Figure 2.

FIGURE 1.
C/SCSC DEFICIENCY IMPLEMENTATION MATRIX

SOURCE (DATA) / DEFICIENCY CATEGORY	Lessons Learned C/SCSC Study (1975)	Air Force C/SCSC Review Observation #1	Navy C/SCSC Review Observation #2	C/SCSC Tri-Service Presentation Observation #3	Management Consultant Interview Observation #4	Feedback, CPMC Student Population and C/SCSC Seminars Observation #5	Consortium of Defense Contractors Observation #6	A. D. Little C/SCSC Survey Observation #7	TOTAL FREQUENCY OF OCCURRENCE
1. etrofit C/SCSC appl.	x								1
2. Premature demonstrations	x								1
3. Lack of PO involvement	x			x					2
4. Lack of HQ guidance	x								1
5. Plant representatives	x			x					2
6. Top management support	x						x		2
7. Analysis/use of data	x	x	x	x	x	x			6
8. Estimate at completion	x		x		x				3
9. Review team members	x	x					x	x	4
10. Planning and budgeting		x			x				2
11. Accounting		x			x	x			3
12. Analysis (variance)		x	x	x		x	x	x	6
13. Earned value			x	x	x	x			4
14. Subcontractor		x	x			x			3
15. Material control			x		x	x			4
16. Reports		x	x		x		x	x	5
17. Training	x	x		x		x	x	x	6
18. Schedules				x		x			2
19. Authorized undefinitized				x			x		2
20. WBS					x	x	x		3
21. Baseline			x		x		x		3
22. Management reserve						x			1
23. LOE application			x						1
24. System discipline			x	x		x			3
25. Revisions					x	x	x		3
26. Work authorization					x				1
27. Non-compliance	x	x						x	2

FIGURE 2. THE C/SCSC DEFICIENCY FREQUENCY DISTRIBUTION TABLE

DEFICIENCY CATEGORY	ORDER OF HIGHEST FREQUENCY *(See Note)	BASIS FOR LESSONS LEARNED TABLE
1. Analysis/use of data	6	VARIANCE ANALYSIS
2. Analysis (variance)	6	
3. Training	6	TRAINING
4. Reports	5	REPORTS
5. Earned value	4	EARNED VALUE
6. Material control	4	MATERIAL CONTROL
7. Review team members	4	REVIEW TEAM
8. Estimate at completion	3	EAC
9. Accounting	3	
10. Subcontractor	3	SUBCONTRACTOR
11. Baseline maintenance	3	BASELINE
12. Work breakdown structure	3	WBS
13. Systems discipline	3	SYSTEM DISCIPLINE
14. Revisions	3	REVISIONS
15. Lack of program office involvement	2	TOP MGMT SUPPORT
16. Top management support	2	
17. Plant representative	2	
18. Planning and budgeting	2	
19. Schedules	2	SCHEDULES
20. Authorized undefinitized	2	
21. C/SCSC non-compliance	2	
22. Lack of headquarters involvement	1	
23. Retrofit C/SCSC application	1	
24. Premature demonstrations	1	
25. Management reserve	1	MANAGEMENT RESERVE
26. LOE application	1	
27. Work authorization	1	

*NOTE: Frequency of occurrence is on attached C/SCSC Implementation Deficiency Matrix.

FIGURE 3. THE C/SCSC LESSONS LEARNED (1987)

SUBJECT	PROBLEM	SOLUTION
VARIANCE ANALYSIS	. Inherent reaction time of variance data not sufficient to predict each individual problem.	. Continue to stress observation of early warning.
	. Documenting superficial detail problems can be time-consuming and non-productive.	. Set variance thresholds to maximize adverse trend analysis.
	. Lack of timely and meaningful data/variance analysis.	. Stress not only variance thresholds. . Quantify the variance. . Describe the problem and its impact on cost, schedule and other elements. . Recommendation/corrective actions. . Emphasize program manager involvement.
	. Too stringent threshold requirements (Retards proper management and analysis).	. Thresholds should vary depending upon size and sensitivity of reporting element.
	. Value of Cost Performance Report (CPR) schedule variance may not indicate a real schedule problem.	. Don't ignore the schedule variance; it is a preliminary indicator of cost problems and a useful trending tool. . Variance expressed in dollars...conversion to time can be a useful tool.
TRAINING AND IMPLEMENTATION OF C/SCSC	. Lack of consistency in the interpretation of the criteria.	. Provide team members with work instructions; flexible, functional procedures.
	. Lack of training.	. Require formal training for team members. . Small classes and on-the-job training. . Require subteam establishment with at least one qualified member.
	. Lack of C/SCSC emphasis at top levels of management.	. Develop and distribute a C/SCSC newsletter.
	. Lack of understanding of C/SCSC capabilities and limitations. (Government and Industry)	. Special courses for commanders, chief executive officers (CEOs) and vice presidents. . Involve top-level management in the reviews.
	. Lack of consistency in C/SCSC application.	. Annual meetings of C/SCSC review directors and team chiefs. . Involve the participation of the Office of the Secretary of Defense, training institutions, and cross fertilization of the military services on review teams.
	. Preconceived changes directed prior to the scheduled review.	. Educate the contractor about the appeals process.
VARIANCE ANALYSIS	. Analysis and use of the data.	. Improvise ways to help contractor and government analyst to better appreciate the value of the data and emphasize a greater understanding of how to analyze and utilize the data.
REPORTS	. Excessive data/reporting requirements.	. Validate proposed requirements and review current requirements. . Educate personnel on optimal data needs.
	. Delayed reporting of materials and subcontract cost variances.	. Require tracking in Format 5 of performance against a material cost baseline as material commitments and subcontract awards are made.

FIGURE 3. THE C/SCSC LESSONS LEARNED (1987) (Continued)

SUBJECT	PROBLEM	SOLUTION
REPORTS (cont'd.)		. Require monthly adjustments of EAC based on reported material cost variances and actual commitment.
	. Lack of reconciliation of external reports with the CPR.	. In Format I, require reporting by cost element (labor, material and other direct). . Reconcile CPR with Contractor Cost Data Report (CCDR). (Aids in cost rejections.)
	. Timeliness of the reports, and quality of the variance analysis.	. Service focal points should assure that the contractor is aware of the need for timely and quality data for the reports to yield their maximum utility. Use the contractual vehicle to assure compliance. . Incremental submittal of CPR Formats. . Implement the use of electronic data transmission when possible.
EARNED VALUE	. Insufficient measurement techniques. (Too much level of effort (LOE))	. Avoid use of LOE. . Use all available quantitative, objective measurement techniques. . It is better to revert to subjective assessment techniques rather than allow higher percentage of LOE. . Maximize ratio of measurable vs. LOE to prevent distortion of performance measurement.
	. Mix of LOE within discrete cost accounts.	. Mixture is allowable within certain guidelines and constraints.
MATERIAL CONTROL	. Lack of material accountability and status on contracts.	. Ensure that the system provide visibility into the entire material status of contract. a. Should be identified in WBS element. b. People responsible for material. c. Earned value for material.
ESTIMATE AT COMPLETION (EAC)	. Adequacy of EAC projection difficult to assess: Frequency, application of automation, application of unreliable overhead rates.	. Evaluate EACs by trend analysis. . Require periodic detail EAC preparation. . Intensify use of "Cum-to-date" cost variances.
	. Cost growth tends to occur in steps. Reluctance of manager to admit growth. Time constant between problem identity and cost impact.	. Supplement manager estimates with parametric techniques. . Allow for program uncertainties when establishing management reserve (MR).
SUBCONTRACTOR	. Lack of subcontractor visibility. (Sometimes the subcontractor does not appear in the prime contract work breakdown structure (CWBS).	. Management Control System flowdown required. . Must be addressed in solicitation and contracts clause. . Prime tasked to perform validation and surveillance to subcontractor.
	. Subcontractor reporting non-standard.	. Should be compatible with the prime, via CPR, C/SSR with required procedures for taking BCWP.
	. Subcontractor EACs.	. EACs must be monitored for the subcontractor.

FIGURE 3. THE C/SCSC LESSONS LEARNED (1987) (Continued)

SUBJECT	PROBLEM	SOLUTION
BASELINE	. Baseline establishment and control. (Weak relationship between WBS and statement of work (SOW).	. Internal trace of work from contract line item numbers (CLINs) to SOW, to WBS cells/WBS dictionary.
	. Baseline not representative of all work on the contract.	. Baseline should reflect status of authorized unpriced work. . Subcontractors must appear in the baseline.
SYSTEM DISCIPLINE	. Manufacturing cost accounts —Inappropriate WBS levels. —Arbitrary time spans.	. Establish cost accounts at meaningful cost account levels. . Allow cost accounts to represent total task.
	. Multiple budgeting and tracking techniques. . Government/contractor system understanding.	. Adapt system to internal methods. . Establish working rapport with government surveillance monitors.
	. System not in use for years.	. Establish internal focal points. . Periodic self-audits. . Use system to manage all programs.
	. Authorizations —Approval signatures dated after work starts, or no dates. —Many log entries dated the week before the arrival of the review team.	. All authorizations which include task, budget, and schedule. . Maintain current logs for changes, MR and undistributed budget.
REVISIONS	. Authorized undefinitized work. (Not incorporating effort into the PMB can jeopardize contract performance.)	. Obtain Procuring Contracting Officer (PCO) Authorization to proceed and incorporate proposal/NTE value as an authorized undefinitized change.
	. Timeliness of internal changes.	. Changes require immediate incorporation into the baseline.
SCHEDULES	. Lack of schedule traceability (horizontal) detailing interdependencies: —Problem (intermediate level schedules) no horizontal trace between key events and major milestones. . Lack of sufficient predecessor-successor identification.	. Contractual requirement for submission of network schedules. . Expansion of intermediate schedules to identify interdependencies. . Require quarterly submission of summary network.
MANAGEMENT RESERVE	. Reserve source must not be speculative (e.g., labor rate windfalls).	. Segregate reserves for labor rate fluctuation from technical or program contingencies.
	. Criteria for application must be definitive and restrictive.	. Reserves should be controlled by higher management.

Conclusion

This article tells the C/SCSC story and provides corporate memory of C/SCSC problems/solutions from 1968-87. The data were gathered from a cross-section of government and industry program management sources throughout the country.

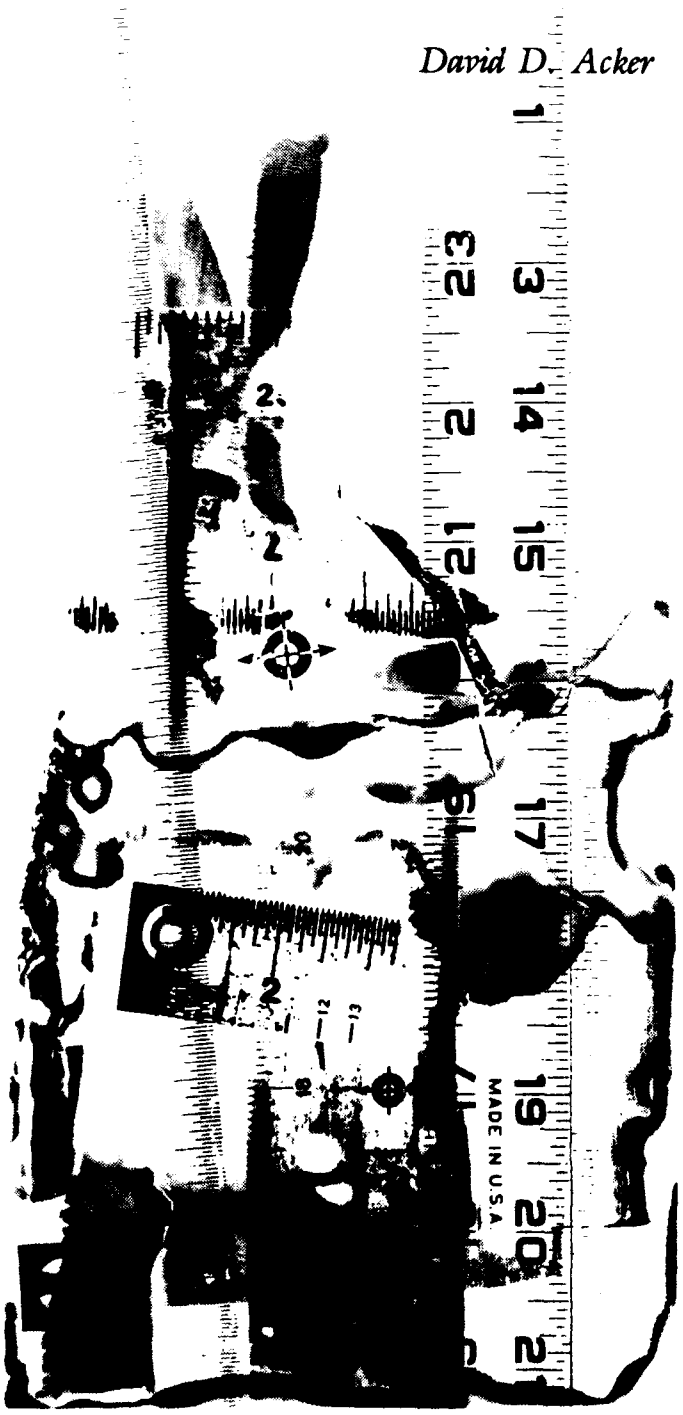
Overall, this data reflects a history of steady progress toward successful implementation of the discipline. Much of the data indicates there has been a transition from problems of implementation to analysis and use of data. Training and analysis and use of data stood out as priority among the problems currently associated with implementing C/SCSC. The data also indicate that the discipline still lacks the kind of top management support that is conducive to future success in implementing C/SCSC. This suggests that government and industry top management should be more involved in the review process and perhaps a top-level management C/SCSC course should be established.

Nonetheless, in collecting this data it became obvious there was a lack of consistency in how C/SCSC data has been collected over the years. It has ranged from that of subjective surveys to frequency of deficiency occurrences. Based on this observation, I recommend establishing a set of standard parameters for data collection for Air Force, Army, Navy, NSIA, and other C/SCSC data sources. In time, this collection of a standard data set will provide a greater opportunity to analyze, compare and extract pertinent information from our C/SCSC data bases.

Dr. Webster is a Professor of financial management at the Defense Systems Management College.

MEASURING & MANAGING QUALITY & PRODUCTIVITY ON DEFENSE PROGRAMS

David D. Acker



This fall, a document will be issued describing the best practices in quality and productivity measurement and management on defense systems. Those of us concerned with preparing this document hope it will gain widespread acceptance in the defense and aerospace industry because current practices need to be, and can be, improved.

The importance of measurement was recognized by Lord Kelvin in 1883 when he stated: "I often say that when you can measure what you are speaking about and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter may be."[1]

We should not deal with quality and productivity as though they are intangibles. Rather, we should deal with them in numbers; otherwise, results will be of "a meagre and unsatisfactory kind."

The "Creed for Productivity Improvement," as stated by J. L. Riggs and G. H. Felix in their textbook on productivity, underlines an important point I would like to make.[2] According to these writers,

> To improve productivity you must manage.
> To manage effectively, you must control.
> To control consistently, you must measure.
> To measure validly, you must define.
> To define precisely, you must quantify.

Quality and productivity measurement and management, once considered to be arduous tasks have been improved, but can be improved further. Recognizing this, some knowledgeable people working in university-based productivity centers and leading defense industrial firms in the United States have been engaged in a five-year, five-phased, management-oriented quality and productivity project, funded by the Department of Defense, to see how and where improvements might be made. Findings have been reviewed by an industry advisory group,[3] and the Office of Secretary of Defense and military service representatives at selected checkpoints throughout the project. Results will be published in the fall.

I participated in the project from the beginning and served as the contracting officer's representative for three of the five years. This landmark project addressed important issues in quality and productivity measurement and management on defense programs. Before publication the guide, setting forth project results, is being reviewed and evaluated by executives and managers of industrial firms, and the Office of the Secretary of Defense (OSD) and Military Department representatives. The guide will incorporate recommended changes.

Let's review project phases leading to preparation and publication.

TABLE 1. MODELS AND METHODOLOGIES FOR MEASURING PRODUCTIVITY

MODEL/ METHODOLOGY	DESCRIPTION
Total Factor Productivity Measurement Model (TFPMM)	The TFPMM is a dynamic, aggregated, indexed, and computerized approach to measuring productivity. TFPMM can be utilized to measure productivity changes in labor, capital, materials, energy and data/information. It measures the corresponding effect each one has on profitability. The TFPMM is based on the premise that profitability is a function of productivity and price recovery; that is, an organizational system can generate profit growth from productivity improvement and/or from price recovery. Productivity relates to quantities of output and quantities of inputs, while price recovery relates to prices of output and costs of inputs.
Cost Definition Methodology (CDEF)	The Price Waterhouse CDEF methodology is an approach for preparing cost baseline data in support of factory modernization efforts for both commercial factories and factories participating in the Department of Defense Industrial Modernization Incentives Program (IMIP). CDEF utilizes a top-down analysis technique which facilitates the identification of appropriate performance and cost measurement criteria, selection of improvement opportunities (through capital investment and/or efficiency improvements), and economic justification of identified investments.
Discounted Cash Flow/ Shared Savings Approach (DCF/SSA)	The DCF/SSA model consists of (1) a time-phased model of cash receipts (or savings) and cash disbursements over a finite planning horizon, with a portion of the receipts being shared savings, and (2) a calculated internal rate of return measure of economic effectiveness.
LTV Integrated Productivity Measurement Model	The LTV model incorporates elements of the TFPMM, CDEF, and DCF/SSA methodologies for measuring productivity.

Summary of Efforts By Project Phase

Phase I was conducted under leadership of Monte Norton and Wayne Zabel at the Army Procurement Research Office (APRO), Fort Lee, Va., with encouragement from Dr. Richard A. Stimson, then Director of Industrial Productivity, Office of the Under Secretary of Defense (Research and Engineering).[4] The effort involved a survey of then-current productivity measurement and evaluation techniques used in the defense industry. Some definitions relative to contractor productivity, acceptable to the defense industry, were developed.

The *Phase I* study revealed several things.

—As a performance evaluation factor, industrial contractors ranked productivity below profitability, effectiveness, quality, and efficiency.
—Problems encountered in industrial firms' attempts to measure productivity are usually caused by difficulties experienced in identifying and quantifying inputs and outputs.
—Visibility of production costs varies widely in industry. In addition, visibility of indirect costs is becoming more important because of shifts in cost drivers.
—Tracking the impact of improvement interventions is difficult, especially in indirect cost areas.
—Investments are made more often for competitive and technological reasons than for reducing costs on current contracts.
—Industry must learn to integrate conventional and new approaches to performance measurement and evaluation, applying them when and where appropriate.[5]

Phase II was conducted by the Oklahoma Productivity Center at Oklahoma State University, and the Maryland Center for Productivity and Quality of Working Life at the University of Maryland, under contract to the Air Force Business Research Management Center (AFBRMC). Colonel Ronald Deep, USAF, Director of AFBRMC, was the contracting officer's representative. This phase focused on identifying and describing available productivity measurement techniques and developing a taxonomy of productivity measurement theories and techniques.

Phase II concluded three things.

—Knowledge of specific productivity measurement techniques is not widespread.
—State-of-the-art techniques require substantial efforts to implement.
—Some macro-measurement and sur-

rogate techniques may be adequate for a specific manager's needs.[6]

Phase III was conducted under contract to the Defense Systems Management College (DSMC) by the Virginia Productivity Center (VPC) at Virginia Polytechnic Institute and State University. Dr. D. Scott Sink, Director of VPC, was principal investigator. This phase focused on evaluating productivity measurement techniques identified in Phase II; i.e., Total Factor Productivity Measurement Model (TFPMM), Price Waterhouse Cost Definition Methodology (CDEF), Discounted Cash Flow/Shared Savings Approach (DCF/SSA), and LTV Integrated Productivity Measurement Model. Models and methodologies for measuring productivity are presented in Table 1. Four subcontractors plus principals directly involved in Phase III were the Maryland Center for Productivity and Quality of Working Life, Dr. Thomas C. Tuttle; LTV Aircraft Products Group, Shoni Dhir; Price Waterhouse, Betty Thayer and William Muir; Westinghouse Defense Group, Richard Engwall.

Phase III concluded several things.

—Individually, none of the first three models evaluated could accomplish all objectives desired by industrial firms or government.

—A methodology incorporating a variety of measurement and evaluation models is required. Models, when integrated (as was done by LTV), constitute a potentially satisfactory methodology to accomplish industry and government objectives; that is, industrial firms want to improve competitiveness and profits. On the other hand, the government wants to lower acquisition costs and improve product quality.

—Variances in organizations, management styles, pressures, priorities, perceived problems and opportunities, and skilled/competent management personnel make it difficult to translate and transfer models and methodologies from one company to another.[7]

Phase IV was conducted by the Virginia Productivity Center and the subcontractors identified previously, under contract to the Defense Systems Management College with funding provided by the Office of the Secretary of Defense. This phase consisted of a field test of the TFPMM, CDEF, and DCF/SSA and the LTV Integrated Productivity Measurement Models; completion of the productivity management methodology designed in *Phase III*; design and development of a draft guide to communicate philosophies, principles, tools, and techniques of quality and productivity management (generally referred to as performance management); and development of detailed plans for evaluation workshops to be held in *Phase V*.[8,9]

Phase V is conducted by the Virginia Productivity Center and subcontractors identified previously under contract to the Defense Systems Management College with Office of the Secretary of Defense funding. The goal is to complete and publish the guide drafted in *Phase IV*. Feedback from an evaluation workshop during this phase should enhance the quality of the guide before release.

The Guide

The guide will describe good performance measurement and management practices used in the defense industry in America today. Dr. Sink and Paul Rossler, the project manager, and members of the project team are convinced the measurement and management practices described in the new guide will help each organization achieve and maintain a competitive position in the defense system acquisition business in the 1990s and beyond.

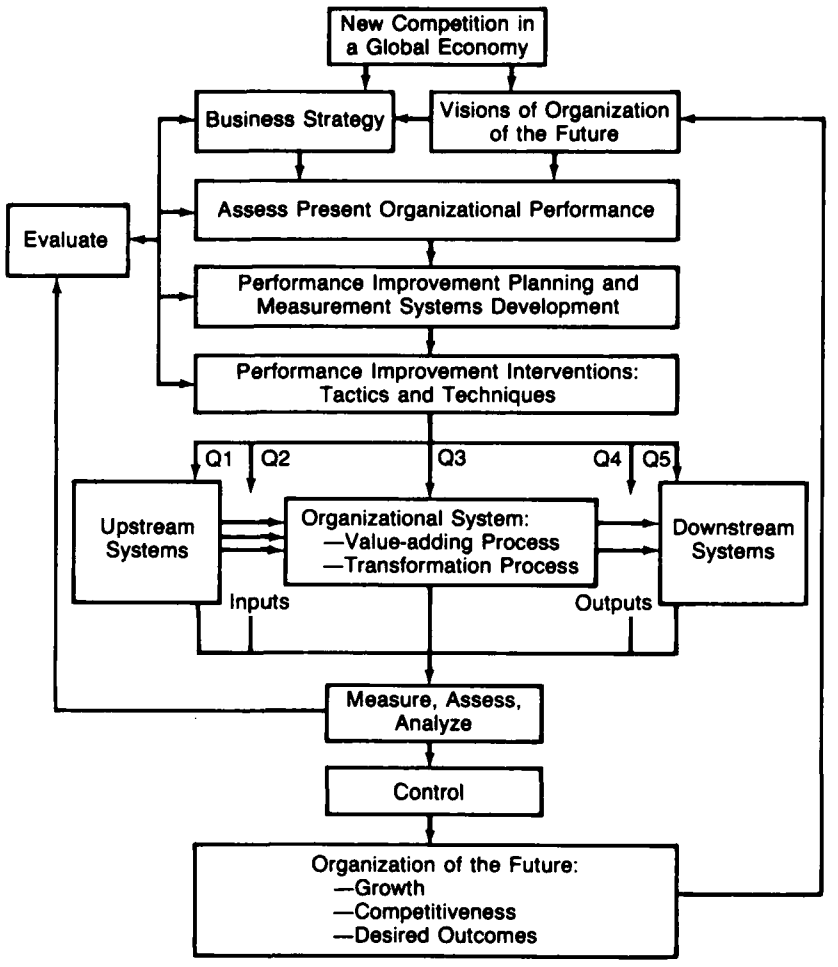
The performance management process, which is easy to conceptualize (see Figure 1) is not easy to place in operation. If a manager understands the basic process, but fails to obtain a proper understanding and agreement within the organization on the process and specific tools needed to effectively implement it, that organization will not reach its goal.

The process shown in Figure 1 may appear complex at first glance; however, it is a simple depiction of how many excellently run companies in America measure and manage quality and productivity. It depicts the organization as an open system with various feedback loops from the environment, and it highlights interrelationships among components of a performance management process.

The Guide will describe good performance measurement and management practices used in the defense industry in America today.

Probably the best place to start describing the model is in the middle with the box titled "Organizational System." This box represents the system being managed. It could be a company, division, plant, or department. The system has upstream systems (internal and external suppliers and vendors) which provide inputs in the forms of labor, material, capital, energy, and data/information. The system takes these inputs and converts them into outputs in the form of goods and services. Downstream systems (internal and external customers) react to these outputs, creating outcomes (customer satisfaction, readiness, profitability).

FIGURE 1. THE PERFORMANCE MANAGEMENT PROCESS



At the top of Figure 1 is the new competition the organization must respond to in order to compete in a global economy. This new competition and global economy influence company business strategy and company visions of the organization of the future. The company assesses its present performance, and uses this data as a foundation for developing plans for performance improvement. Key performance indicators are identified to provide the company with feedback on its progress.

Out of the performance improvement planning process comes specific performance improvement interventions, tactics and techniques. Note that these interventions happen at five quality checkpoints: (Q1) upstream systems; (Q2) inputs; (Q3) process; (Q4) outputs; and (Q5) downstream systems. After interventions to the system have been made, performance is measured, assessed, and analyzed at the five quality checkpoints to determine whether the impact the interventions were to have made on the system actually occurred. Based on this data, an evaluation relative to the company's business strategy, environment (internal and external), vision, plans, and improvement interventions are made. Note that the process of evaluation is separate from the process of measurement. Measurement supports improvement and this, of course, is of primary interest.

If a company has an effective, high-quality management process in the areas of planning, measuring and evaluating, and controlling and improving, it will achieve its vision of the future, and its desired outcomes.

Before I comment on the guide in more detail, it is important that you have a basic understanding of the quality and productivity terminology used.

Definitions of Basic Terms Used in The Guide

The definitions listed below apply.

Effectiveness. The degree to which a system accomplishes what it sets out to accomplish.[10]

Efficiency. A comparison among resources expected to be consumed to accomplish a specific goal, task, or objective and resources actually consumed to reach that goal, accomplish the task, or meet the objective.[11]

Innovation. Creative process of adapting products, services, and processes to changing internal and external pressures, demands, changes, and needs. It might be called the process of maintaining fitness for use from the customer's viewpoint.

Performance (Quality and Productivity) Management. Process which includes planning, measurement and evaluation, control, and improvement. Figure 1 depicts the general flow of the performance management process.

Productivity. Relationship of the quantity of output goods and/or services obtained from an organizational system for some period of time to the quantity of input resources consumed by that organizational system for the same period of time, quality considered.

Productivity Improvement. Result of managing and intervening in key transformation processes. Productivity improvement occurs when any of the

following conditions are made to exist:

—Output increases and input decreases
—Output increases and input remains constant
—Output increases and input increases but at a lower rate
—Output remains constant and input decreases
—Output decreases and input decreases but at a more rapid rate.

Productivity Measurement.[12] Selection of physical, temporal, and/or perceptual measures for input variables and output variables, and the development of a ratio of output measure(s) to input measure(s). A good productivity measurement system will indicate to management when there is a need to plan and act, and provide clues where in the system to intervene.

Profitability. Ability to yield advantageous results. It is a measure, or set of measures, of the relationship among financial resources and their uses, such as return on assets and return on investments.

Quality. Degree to which a system conforms to requirements, specifications, and expectations. To be managed effectively, quality must be defined relative to five quality checkpoints, namely:

Q1: Selection and management of upstream systems (internal and external suppliers and vendors)

Q2: In-coming quality control

Q3: In-process quality management

Q4: Out-going quality control

Q5: Proactive and reactive assurance of customer satisfaction.

These checkpoints were highlighted in Figure 1.

Quality of Work Life. Efforts to increase performance through improvement in psychosocial rather than technical and structural systems.

Total Quality Management. Management system including all five quality checkpoints. (See "quality" definition.)

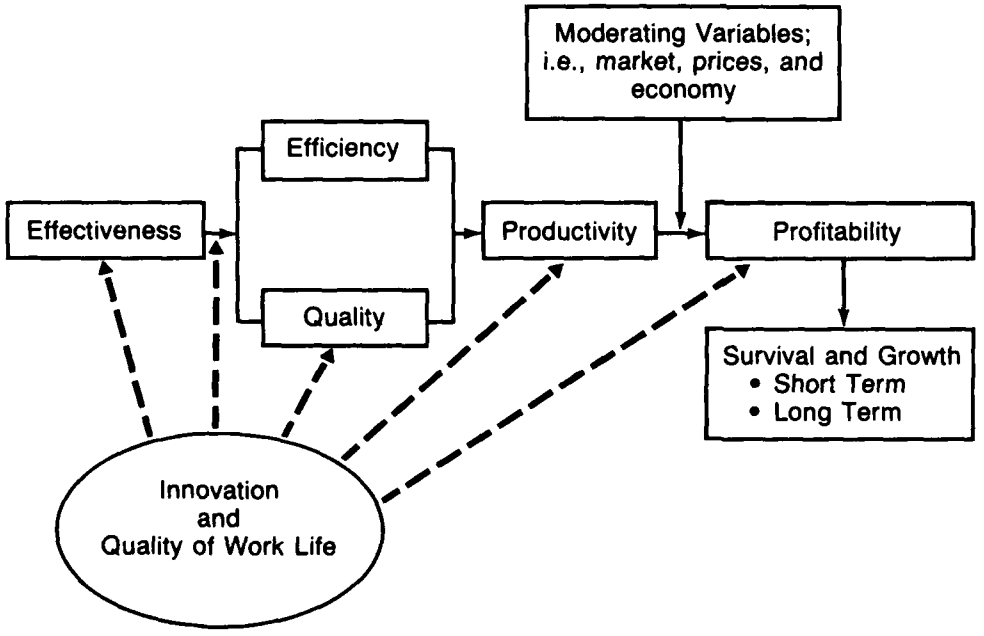
Performance of an organization is a function of many of the criteria already defined. Conceptually, these criteria are interrelated in the manner shown in Figure 2.

Desired Outcomes for the Guide

Those playing parts in developing the guide hope it will do the following:

—Communicate fundamentals of performance management methodology
—Establish role and importance of productivity measurement and management
—Move people in government and industry away from a narrow view of productivity measurement and management
—Demonstrate that measurement leads to improvement
—Demonstrate that measurement supports incentive methodology.

FIGURE 2. THE CASUAL RELATIONSHIPS AMONG PERFORMANCE CRITERIA



Design Criteria for the Guide

The design criteria, agreed to by the team in the fall of 1986 and revised in 1987, are shown below.

—Prepare a guide written from the contractor's perspective and responsive to contractor and government needs

—Present a procedure for designing a grand strategy for quality and productivity improvement

—Explain role of measurement in performance improvement efforts, especially the link between measurement and incentive methodologies

—Identify and describe, in succinct form, government-to-contractor incentive methodologies

—Explain the Total-Factor Productivity Measurement Model, Price Waterhouse Cost Definition Methodology, Discounted Cash Flow/Shared Savings Approach, LTV Integrated Productivity Measurement Model, and other surrogate measurement tools and techniques

—Document a technique that can be used to evaluate existing and proposed productivity measurement and management systems

—Provide a balanced view of the performance management process

—Discuss philosophy for making performance management and improvement a way of life

—Test, before formal publication, the guide credibility to government and contractor personnel.

Concept of Guide

The guide will set forth state-of-the-art practices based upon the knowledge, wisdom, and experience gained during the past ten years or so. It will reflect an appropriate blend of rigor and relevance, theory, technique, and practical applications. It will present practices in use today in some of the excellently managed manufacturing firms in America. The guide will be organized around a generic model (Figure 1) for performance management. It will provide a logical flow of the performance management process.

> The Guide will reflect an appropriate blend of rigor and relevance, theory, technique, and practical applications.

Chapter 1. The Challenger. *What the Defense Contractor of the Present Faces.* This chapter concerns the tremendous stress that our global, dynamic economy is creating on American organizations. It explains that increased competition is forcing management teams to reexamine basic practices. It states how we do business must be scrutinized and modified.

Chapter 2. Visions. *What the Defense Contractor of the Future Must Look Like.* Shared, well-communicated visions of the future are critical to achieving desired outcomes in the defense industry. Thus, the performance management process logically begins with a focus on visions, guiding principles, missions, and outcomes.

Chapter 3. The Responses. *Strategy and Plans for Continuous Quality and Productivity Improvement.* This chapter provides an overview of the performance management process. It explains the process and shows how the process can be a "roadmap" for an organization's performance management efforts. This chapter provides a detailed outline of what follows in the guide. This chapter discusses how to create plans for quality and productivity improvement. It also focuses on a critical and oftentimes troublesome element of performance management, the planning process.

Chapter 4. Measurement. *Theory and Approaches: How to Build Quality and Productivity Measurement Systems.* This chapter presents the theory of measurement and the approach for building measurement systems. Critically important philosophy and foundation concepts that must guide measurement efforts are provided. The distinction between measurement systems for control and improvement are discussed.

Chapter 5. Measurement Techniques. *How to Measure Quality and Productivity.* This chapter explains the measurement techniques. Various models are presented for consideration.

Chapter 6. Improvement. *Strategies to Make Quality and Productivity Improvement Happen.* This chapter explains how to improve quality and productivity. It provides a structural overview of the state-of-the-art. Many unique techniques are presented in a step-by-step, flow-process fashion.

Techniques include recent techniques used in performance management efforts; e.g., government-to-contractor incentive methodologies (industrial modernization incentives program), contractor-to-employee incentive programs, total quality management and participative management.

Chapter 7. Maintaining Excellence. *How to Make Quality and Productivity a Way of Life.* The final chapter is devoted to maintaining excellence in performance management. It's a tough task to sustain a culture supporting constant improvement and innovation. The reader should be challenged to think about the organization of the future. Questions like these will be raised: How does an organization function using concepts and techniques presented in this document? How does one keep moving toward a vision while simultaneously and continually updating the vision?

Conclusion

Measuring and managing quality and productivity at the close of the 1980s, and into the 1990s, will continue to be complex. This is partly the result of the complex interrelationship continuing to exist among government entities, competitors, the economy, technological advances, and the uncertain environment. Therefore, implementing even the simplest concept or technique presented here will be a challenge for any organization, industrial firm or government entity.

The need for a guide is evident. The guide presents in a clear and succinct fashion a structured approach to performance management based on good practices being used successfully in 1988.

Although implementation of models and methodologies set forth in the guide will not ensure success, organizations using them properly will be more apt to succeed in performance management than those who do not. We should recognize that quality and productivity are not always what they seem to be on defense system programs. Realities of a manager's expectations call to mind these lines from Act II of Gilbert and Sullivan's *HMS Pinafore*, which I had the pleasure to see again recently:

> Things are seldom what they seem,
> Skim milk masquerades as cream
> . . . . . .
> Storks turn out to be but logs,
> . . . . . .
> Bulls are but inflated frogs.
> Gild the farthing if you will.
> Yet it is a farthing still.

Many factors influence a manager to gild the quality and productivity farthing. The successful manager will be able to show it is possible to do more with less while using techniques not always understood by others and, sometimes, without an incentive for meaningful improvement.

Endnotes

1. Lord Kelvin (William Thomson), British scientist, supervised the laying of the first successful transatlantic cable and patented 70 inventions. He received the title of Baron Kelvin of Largs in 1892. Because of his discoveries about sound, light, heat, and electricity, he is recognized as one of the greatest scientific intellects of his time.

2. Riggs, J. L., and Felix, G. H., *Productivity by Objectives*, Englewood Cliffs, N. J., Prentice-Hall, 1983.

3. Members of the Industry Advisory Group who participated in this project were from the following companies: Allied Bendix, Bell Helicopter, Boeing, Garrett, General Dynamics, General Electric, Grumman, Hercules, Honeywell, Ingalls Shipbuilding, LTV, McDonnell Douglas, Price Waterhouse, Raytheon, Rockwell International, Sierracin/Sylmar, Simmonds, Sundstrand, Texas Instruments, TRW, and Westinghouse,

4. Since retirement of Dr. Richard A. Stimson from the federal government in 1986, Douglas Reeves (now retired), Gordon A. Frank, and Kurt Greene, all from the Office of the Secretary of Defense, have kept a watchful eye on this project.

5. Report of the Army Procurement Research Office (APRO) Number 83-01, subject: "Contractor Productivity Measurement," June 1984.

6. Report of the Air Force Business Research Management Center (AFBRMC) Number BRMC-83-5071, subject: "Development of a Taxonomy of Productivity Measurement Theories and Techniques," February 1984.

7. Report by the Virginia Productivity Center (VPC), subject: "The Study of Productivity Measurement and Incentive Methodology (Phase III-Paper Test)," 3 volumes, March 1986.

8. Report by the Virginia Productivity Center, subject: "The Study of Productivity Measurement and Incentive Methodology (Phase IV-Field Test)," March 1987.

9. *Masters of Change: A Joint Defense-Industry Guide to Quality and Productivity* (Draft).

10. Peter Drucker defines *efficiency* as "doing things right" and *effectiveness* as "doing the right things."

11. Ibid.

12. According to Peter Drucker, "...In turbulent times, the first task of management is to make sure of the institution's capacity for survival, to make sure of its structural strength and soundness, of its capacity to survive a blow, to adapt to sudden change, and to avail itself of new opportunities.... Without productivity objectives, a business does not have direction. Without productivity measurement, it does not have control."

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PROTOTYPES

Calvin Brown

Lately, the term "prototype" has been used extensively in articles, books and journals dealing with the acquisition of weapon systems and equipment. However, the term is rarely defined and the reader is left to determine his or her perception of which meaning the author intended. This article is intended to look at kinds of prototyping and, in the process, clear up some confusion.

In the final report of the President's Blue Ribbon Commission on Defense Management (Packard Commission), competitive prototyping, either at the system or critical subsystem level, was recommended for all major weapon systems. In the advanced development phase of a program (concept demonstration/validation phase of a major system), this prototyping would involve an informal competition of ideas and technologies rather than a formal competition based on cost. Early operational testing, and developmental testing, should be performed to uncover operational and technical deficiencies before entering full-scale development (FSD). At this stage it is still relatively inexpensive to correct operational and technical deficiencies uncovered during testing of the prototypes.

> Early operational testing and developmental testing should be performed to uncover operational and technical deficiencies before entering full-scale development.

The Department of Defense Appropriations Act for fiscal 1987 mandated that all major weapon systems entering advanced development after September 30, 1987, must include a competitive prototype strategy. The act requires that contracts be entered into with at least two contractors, and requires that systems and subsystems developed undergo comparative side-by-side tests. Contrary to the Packard Commission concept of "competitive prototyping," each contractor developing a prototype system or subsystem is required to submit cost estimates for full-scale development and production estimates, where practicable, before testing begins. When competitive strategy is not practicable, the Secretary of Defense must submit written notification to the Congress explaining that position. The latest revision of Department of Defense Directive 5000.1 reflects this mandate.

The previous discussion reflects the meaning of "prototyping" as defined in the DSMC *Glossary of Defense Acquisition Acronyms and Terms:* "An original or model on which a later item is formed or based. Usually built during Demonstration/Validation and tested prior to Milestone II decision." This is normally referred to as an "engineering" or "experimental" prototype and is the meaning most often inferred by the term "prototype."

A second kind of prototype is "preproduction" which is developed during full-scale development and represents the production configuration in all aspects of form, fit, and function except that it has not been fully qualified in terms of environmental and operational testing. A preproduction prototype is produced for the purpose of final system/equipment/software test and evaluation before entering the production phase. Its purpose is to verify design accuracy to the maximum extent practicable at this stage of the life cycle.

In software development, an alternative to the normal system life-cycle development approach is an evolutionary design method called "prototyping." Software prototyping is particularly useful when requirements are difficult to specify in advance, when requirements may change significantly during development, or when user-developer communications are indirect or difficult. It is usually easier for users to tell what they do, or do not, like about an existing prototype than it is to express what they would like in an imaginary, undeveloped system. A. Milton Jenkins, University of Wisconsin, defines prototyping as a four-step process to: (1) identify the user's basic requirements, (2) develop the initial prototype, (3) let the user use the prototype to refine requirements, and (4) revise and enhance the prototype. Steps (3) and (4) are normally an iterative process. When that process is performed early in advanced development, with the understanding that the prototype will be discarded after the requirements are refined and that no formal documentation will be delivered, the process is called "rapid" prototyping.

I hope this brief discussion has contributed to your understanding of competitive prototyping, engineering and preproduction prototypes, and rapid prototyping. In a future issue, I will discuss the Navy Rapid Prototyping process for solving urgent fleet war fighting deficiencies.

Mr. Brown is a Professor of engineering management in the Research Directorate at DSMC.

A CAPITAL CRISIS IN THE DEFENSE INDUSTRY?

(A Summary of Three Recent Studies of Financial Health and Investment Attractiveness of the Industry)

Dr. Fred Waelchli

Defense material acquisition in this country is a joint undertaking of three colossal and diverse national institutions: the executive branch, the legislative branch and the defense industry. Needs and interests, institutional and personal, of participants in the acquisition process vary. While there must be a substantial overlap of genuine interests among the three for the acquisition process to succeed, there are important interests that inevitably and properly diverge or conflict. This is a normal situation, and it is the legitimate function of markets and politics to resolve these differences.

A special problem arises, however, if independent actions of two parties combine unexpectedly to threaten serious injury to the third, and thus impair ability of the defense acquisition process to function. Three recent studies independently suggest this situation has happened—that a series of specific actions taken by the Department of Defense and the Congress between 1984 and 1987 have combined to severely threaten the health of the defense industry. This article summarizes these three studies. David Westermann's article, "Government Contract Profit Policy and Defense," in the May-June issue of ***Program Manager,*** *explored ramifications of problems highlighted here.*

Issues raised are serious. You should recognize, however, that these studies originated in the defense industry, and must be considered, to some extent, advocacy journalism. No attempt is made in this article to be even-handed; views expressed are those of the participants in the studies as interpreted by the author. These views are not endorsed by the Defense Systems Management College, ***Program Manager,*** *or any office in the Department of Defense.* ***Program Manager*** *solicits thoughtful, factual, concise, and readable expressions of opposing or divergent views on issues raised in this article.*

The U.S. defense industry is in genuine trouble, and its problems are deepening rapidly. This is the ominous theme of three recent studies of the defense industry, one released in July 1987, and the other two in February 1988.

The studies' common assertion is that a handful of uncoordinated legislative and administrative actions, taken in government in the last five or so years, has fundamentally altered the risk/reward relationship in the defense industry. These actions have simultaneously raised defense contractors' risks and lowered their prospective rewards so that risk-adjusted returns on assets invested in the defense industry are no longer competitive with the range of returns available to capital invested elsewhere. Therefore, we will see (in fact, already see) a significant capital flight from the defense industry, with serious consequences for national security.

Provenance of Three Studies

The first study was by the Financial Executives Institute (FEI) a professional organization of senior financial and administrative officers in U.S. business organizations. The second study was by 13 senior defense industry executives chartered in August 1987 as the *ad hoc* Defense Industry Advisory Group (DIAG) by the Defense Industry and Technology Subcommittee of the Senate Armed Services Committee (SASC). The third was commissioned by three industry associations, National Security Industrial Association, Aerospace Industries Association, and Electronic Industries Association, and was performed by the MAC group.*

A Mare's Nest of Government Acquisition Actions

Each study cited the following governmental actions as significant contributors to an incipient exodus of capital from the defense industry. You should understand what follows is, in each case, a terse and necessarily simplified summary of a complex action or situation.

Special Tooling and Test Equipment Investment Recovery. The Fiscal Year 1987 Defense Appropriation Act (P.L. 99-591) required contractors to capitalize and amortize (rather than expense) costs of investment in special tooling required to make unique products, and costs of special test equipment. The FY 88-89 Defense Authorization Act (P.L. 100-180) wrote into permanent law the requirement for contractor investment in 50 percent of special tooling costs. Legislation makes payment of profit of these investments a matter of governmental case-by-case discretion.

Reduced Rate of Progress Payments. The Fiscal Year 1987 Defense Appropriation Act (P.L. 99-591) reduced progress payments on defense contracts from 80 percent to 75 percent. The earlier rate had been 90 percent or 80 percent, dependent on size of the firm.

Restrictions on Completed Contract Method of Accounting. The 1983, 1986, and 1987 tax-law revisions successively reduced ability of the contractor to defer recognition of, and payment of taxes on, contract profit until completion of the contract. This change results in earlier tax payments, with a consequent negative cash flow and a new need to finance vanished working capital funds.

One Percent Reduction in Profit Margin Markups. The Fiscal Year 1987 Defense Appropriation Act (P.L. 99-591) reduced pre-negotiation profit margin markups by a target of 1 percent of costs or about 10 percent of profits. The law partially offset these reductions with variations designed to reward a contractor for investment in facilities and capital investment.

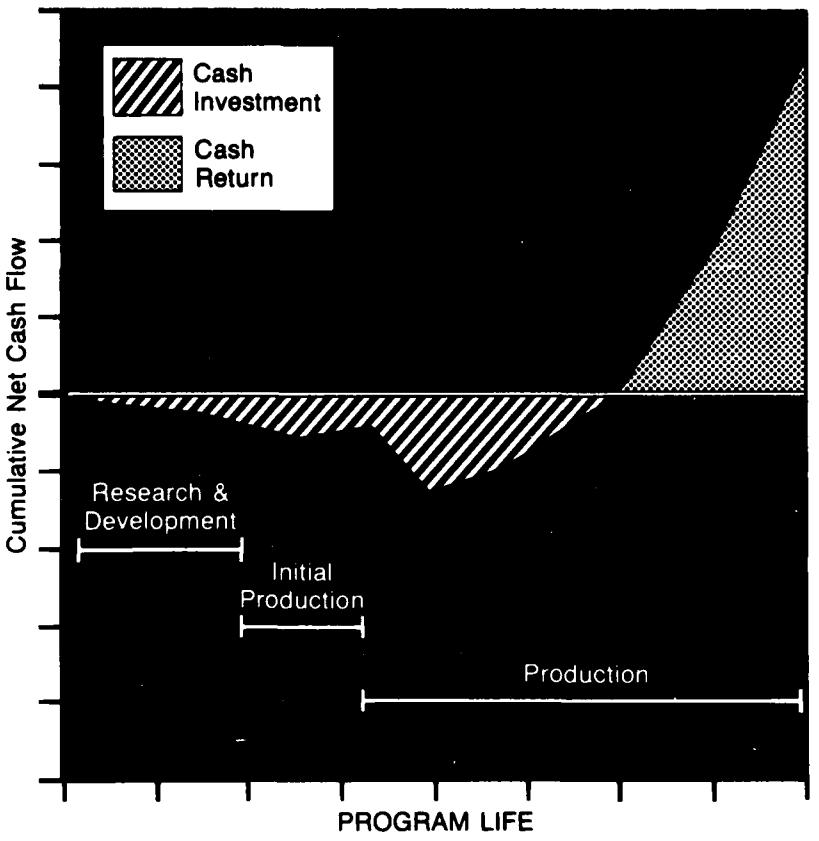
Lower Cost Recoveries. The Congress has capped the amount of Independent Research and Development (IR&D) and Bid and Proposal (B&P) costs the contractor can recover through overhead billing on government contracts, and has prohibited the payment of profit on IR&D. The Congress added to the list of normal and unavoidable costs of doing business that are decreed to the "unallowable" for contract reimbursement purposes.

Transfer of Rights in Data to Government. The Fiscal Year 1985 Defense Authorization Act (P.L. 98-525) required the Department of Defense to issue regulations defining the government's legitimate interests in contractor technical data rights. Complaints of Department of Defense alleged overuse of data rights provisions apparently provoked new legislation (P.L. 99-961; FY 1987 Defense Authorization Act) stating the congressional belief that Department of Defense regulations required contractors to give up too much proprietary information, and directing Defense to rework regulations.

Research and Development Cost Sharing. As a matter of common practice, contractors are frequently required to pay part of the contract research and development costs of new systems, with no guarantee of a follow-on procurement contract in which to recoup the investment.

Fixed-Price Development Contracts. While not a law or Department of Defense policy, it had become custom for some military services to insist on fixed-price contracts for research and development of new systems, and to demand fixed-price production options before the end of product development. The effect has been to shift sizable, usually uncompensated, risk to the contractor. There has been recent action on this issue; the FY 1988 Defense Appropriation Act restricts Department of Defense use of fixed-price development contracts and requires such contracts to be approved by the Undersecretary of Defense for Acquisition.

FIGURE 1. TYPICAL PROJECT NET CASH FLOW

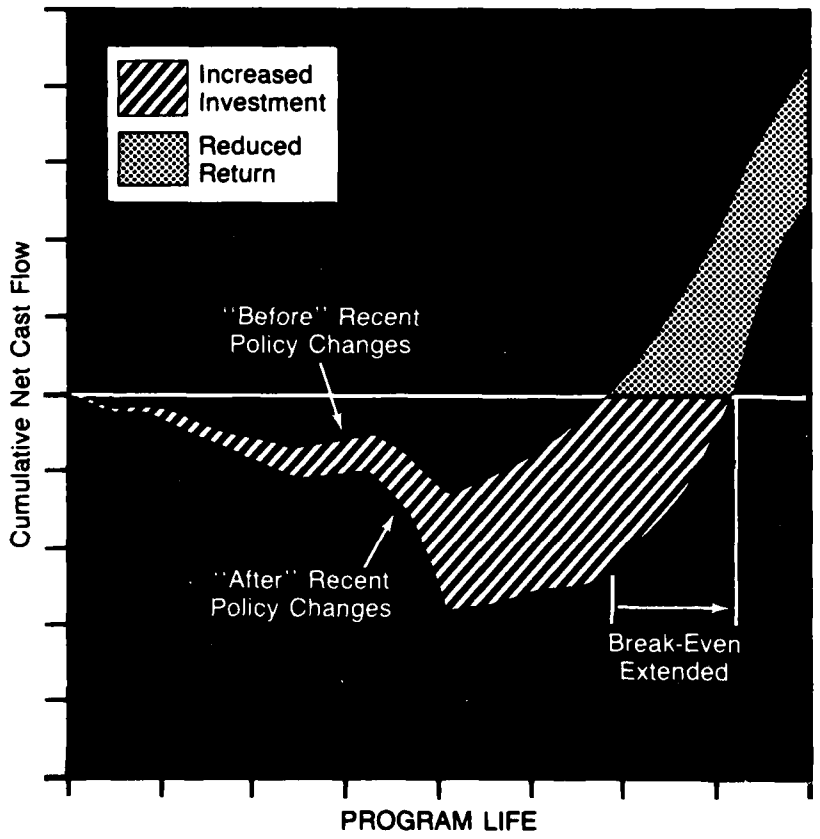


Source: Adapted from FEI Report

SUMMARIES OF THREE REPORTS

Financial Executives Institute Report, The Impact of Government Policies on Defense Contractors, July, 1987. This report uses the device of the cumulative net cash flow diagram to illustrate notionally effects of cited governmental actions. Figure 1 shows,

FIGURE 2. EFFECT OF GOVERNMENT ACTIONS ON PROJECT NET CASH FLOW



Source: Adapted from FEI Report

for an actual 1970 defense program, unnamed, but represented as typical, an initial gentle rate of negative cash flow during research, development, and initial production, which deepens sharply during early volume production, turns up as cash from sales arrives, and reaches positive territory (break-even) toward the end of production.

Figure 2 shows effects the Financial Executives Institute asserts cited governmental actions would have on cash flow for the same project were the project to start today. Early negative cash flow is deeper, requiring the contractor to finance larger sums for longer periods, extending break-even date, and reducing final net positive cash balance. Were cash flows discounted, as is always the case in practice, these effects would be magnified since negative cash flow is early and positive cash flow is late.

The Financial Executives Institute report does not quantify effects it describes, but makes the following predictions based on its analysis:

"Participation in defense contracting by both large companies and smaller specialty companies will be reduced as investment opportunities outside the industry become more attractive. The defense industrial base will shrink and competition will decline because the entry level investment has increased without a corresponding increase in the potential return.

"Internationally, the competitive position of U.S. contractors will erode, with a corresponding negative impact on the U.S. balance of payments.

"Finally, but most importantly, the worldwide technology lead of the U.S. defense industry may not be maintained."

Defense Industry Advisory Group Report to Subcommittee on Defense Industry and Technology, Senate Armed Services Committee, February 5, 1988. The report is the broadest, dealing with acquisition issues beyond the eight governmental actions cited here, but also addressing those actions. The Defense Industry Advisory Group was formed in August 1987 by Senator Jeff Bingaman, chairman, and Senator Phil Gramm, ranking minority member, to advise the Senate Armed Services Committee Defense Industry and Technology Subcommittee on "...those aspects of the acquisition process that stifle innovation, drain good talent away from the acquisition system, and threaten our technological lead."

Chairman John Rittenhouse, General Electric Aerospace Corporation, and the panel identified 20 issues in three thematic areas which they believed adversely affected ability of the current defense acquisition process to provide for needs of the armed forces, and its ability to ensure continued advancement of technology and industrial productivity necessary for national security.

The first Defense Industry Advisory Group theme was "People: the Procurement Workforce, and Organizational Relationships within DOD" (two issues); second, "Process: Streamlining and Stabilizing the Process, Including Issues of Contractor Financing and Investment" (14 issues); finally, "Trust: the Relationships among Congress, the Executive Branch, and Industry" (four issues). The first four problem statements of the "process issues" center on the cited governmental actions and raise the

problem of capital flight from the industry. Those four issues are stated as follows in the Defense Industry Advisory Group study:

"Issue 1: The Conflict Between Profit and Investment Policies. The issue is that government acquisition policy seeks to create incentives for contractors to make investments which benefit the government and to provide reasonable profits from which such investments can be made. This policy became confused over the last two years as a result of conflicting legislative and regulatory initiatives. Without resolution of the conflict, this policy will fail.

"Issue 2: Profits and Costs. Financial policies enacted in recent years to reduce DOD outlays and the federal deficit will increase procurement costs and reduce national security in the long term. Profits account for less than 10% of defense expenditures, while contract costs account for more than 90%. Many of these costs are the result of unnecessary government regulations. Attention should focus on nonproductive costs.

"Issue 3: Government Policy on Independent Research and Development (IR&D). For the past several years, Congress has established ceilings on Government-allowable, Independent Research and Development and Bid and Proposal (B&P) costs. These ceilings inhibit industry investment in advanced technologies and new products.

"This year, Congress will consider whether to alter or eliminate the Government's traditional support for independent research and development. Because IR&D is at the foundation of the technological superiority of our armed forces, the IR&D system should be strengthened as an investment in the future.

"Issue 4: Shifting Undue Risk to the Contractor. Disregarding the lessons learned from failures of similar procurement methods in the past, the DOD is now employing procurement methods which shift unmeasurable risks to contractors in three different ways. *First,* contractors are being required to pay a portion, sometimes substantial, of the development costs of Defense Department systems, under a practice called 'cost sharing'. *Second,* contractors are being required to enter into fixed-price contracts early in development, when the uncertainty is so substantial that it is virtually impossible to know the precise costs of new systems. *Third,* contractors are being asked to provide the Defense Department with priced production options before full-scale development has begun.... All of these requirements shift undue risk to the contractor, drain industry resources from investments in technology and productivity, and will ultimately affect our nation's ability to maintain technological superiority."

> The domestic defense industry is no longer an attractive investment; reward no longer compensates adequately for risk, and capital is fleeing. Strength in the defense industry is migrating offshore.

The Defense Industry Advisory Group Report poses three "...fundamental questions of how DOD should do business," derived from consideration of the cited set of government actions:

"The most essential business equation, in which measurable risk is balanced by profit potential, no longer describes defense business. How can this balance be restored?

"Current policies discourage investment in technology and productivity. How should they be changed?

"Small manufacturing firms *are forced* to pay a high price for participating in the government market by having to give up the fruits of their innovation. What effect does this have on competition?"

The Defense Industry Advisory Group Study is qualitative; like the FEI study, it does not attempt to quantify the effects it describes. It asserts keys to improving the acquisition process are "...streamlining and program stability." 35.

The MAC Report, The Impact on Defense Industrial Capability of Changes in Procurement and Tax Policy, 1984-1987, dated February, 1988. This report is the only quantified analysis among the three studies. It takes the cumulative net cash-flow methodology used in the Financial Executive Institute Report and applies it, with new procurement rules, to actual data from nine historical Department of Defense acquisition programs, all but one profitable, and each managed by a different defense contractor. The intent was to estimate effects of governmental actions on contractor cash flow, now and in the future. Like the Financial Executive Institute Report, the idea was to estimate financial impacts on past programs if the new rules had been in effect. Among their findings:

"The return on investment on the programs analyzed would have been less than the return necessary to preserve shareholder value. Put simply, there would have been no financial reason to bid the programs.

"Profits on current work will be substantially reduced—by an average of 23% on the companies' defense business.

"Companies will be forced to borrow heavily, but the additional financing required will, for some companies, likely exceed the amount that can be borrowed.

"As companies feel the squeeze on available capital, they will be forced to:

—Reduce (already declining) contractor-funded research and development investment.

—Reduce risk by opting for low-technology alternatives.

—Reduce investment needed for productivity enhancement and modernization.

—Decline to bid programs with unrealistic provisions.

"While the full financial impact may not be reflected in the industry's financial statements for three, or even more, years, the industry is already beginning to respond in these terms. The financial impact will probably show first in subcontractor financial statements.

"The governmental changes will result in a less efficient industry. Cutting back on capital investment is mortgaging the future, slowing down the industry's ability to improve production efficiency.

"Competition will be reduced because there will be fewer competitors willing to bid on future programs."

Dismal Message

The composite message of three studies is dismaying. The domestic defense industry is no longer an attractive investment; reward no longer compensates adequately for risk, and capital is fleeing. Strength in the defense industry is migrating offshore. If the present trend goes unchecked, the U.S. defense industry will shrink, competition will decline, technological progress will stagnate, and the quest for preeminent performance in U.S. weapon systems will falter as industry declines to accept the prerequisite development risks.

No one planned for such a situation, and nobody wants it. Why is it now a real prospect?

The Predicament

If we accept the validity of the three studies, the mistake leading into the current predicament was a series of nearly simultaneous, uncoordinated actions by the Congress and the Department of Defense, each logically designed for a limited objective, but whose sum foreshadows a possible national security nightmare.

The way out, in direct contrast to the way in, must be carefully and thoughtfully planned and coordinated by those with power to make changes, the Department of Defense and the Congress.

The first lesson, therefore, is that acquisition is, or takes place within, a complex social system. Complex social systems can be controlled only by well-designed and properly crafted control and administrative devices; "simple" control devices do not control and inevitably produce unanticipated, usually unwelcome, side effects.

The way out, in direct contrast to the way in, must be carefully and thoughtfully planned and coordinated by those with power to make changes, the Department of Defense and the Congress. Proposed actions, singly and in combination, must be tested for impact on the system before they are imposed. The MAC Report argues:

"...Congress should ensure that the type of uncoordinated policy change that led to this unintended utcome is not repeated. The Congress and DOD must undertake some form of impact assessment...before introducing policies whose cumulative impact on the industry is as severe as we have shown.

"...Congress and DOD should develop a clearer vision of the type of defense industry that will be required in five to ten years. It should test its procurement policies against these requirements, and ensure that they provide an incentive to invest in the production facilities and equipment, research, and human resources that the industry and the DOD will require."

In discussing the Defense Industry Advisory Group Report with the Senate Armed Services Committee staff, a Defense Systems Management College faculty team proposed commissioning a major study to examine legitimate needs and interests of the Executive branch, the Congress and industry to see if a viable, "win-win," *modus vivendi*, supportive of national security and acceptable to all stakeholders (some used the word "treaty"), could be devised.

Clearly, there are different ways to approach this problem. Surely we need to start now to construct a reasoned plan to ensure that we will never again find ourselves unwitting victims of fragmented, uncoordinated, contradictory, and ultimately damaging acquisition policy and regulations.

As this article is written, there are signs the capital flight problem is becoming visible to the Congress and the Department of Defense. Senator Bingaman's subcommittee on the defense industrial base heard testimony on two of the three reports I have reviewed. The Department of Defense appears to be backing off on fixed-price development contracts and shows evidence of second thoughts on cost sharing. By now, there may be other changes affecting the capital-flight problem.

As yet, however, there is no sign of a coordinated, thoughtful, strategic ap-

proach toward defining or crafting the optimum or desired relationship between government and the defense industry. There is every evidence that we are proceeding to "piecemeal" our way out of the predicament just as we "piecemealed" our way in. Thus, we guarantee no reasoned or long-term systemic solution to the structural problem.

Specific Approaches to Capital-Flight Crisis

What can be done to resolve today's apparent defense industry capital flight crisis? Here is a portion of the MAC Report's response:

"Our study makes explicit an issue that DOD procurement policy must face. Business is fundamentally about risks and returns. As essentially the only purchaser of highly specialized defense equipment, DOD controls both sides of the risk/return balance (at least for major systems procurement). In the period we have examined, DOD and the Congress decided to adjust what was viewed as an imbalanced risk-return relationship. Unfortunately [they] reduced rewards and increased risks simultaneously, with not one, but multiple, uncoordinated adjustments. At the same time, Congress significantly increased the industry's capital requirements (by reducing progress payments and deferred tax financing).

"While some in DOD now claim the industry is much more like commercial industry, Wall Street is saying it will not provide it with capital at the same rate as commercial industry. Wall Street might provide the capital if it saw the opportunity for high returns (as it does for biotechnology companies, for example); the industry might live with low profits if the government provided more of the financing and did away with cost sharing, fixed-price development, and other unreasonable risks. But, as matters currently stand, government has stepped out, Wall Street is unwilling to step in, and the industry is unable to.

"Solutions have to address both profitability and risk, which have to be in balance. This introduces the question of what is the appropriate balance?"

What is the appropriate and politically acceptable balance between profitability and risk in the defense industry? That seems to be the question to answer soon in a coordinated way by everyone concerned.

Bottom Line for Industry

Individual governmental actions in the three reports are complicated, and contributions of each action to the general problem are difficult to assess, as each study makes clear. The overall issue, however, could not be simpler.

As a nation, we choose to acquire military material and equipment through a privately financed, privately managed, free, and non-coercive market system. In this system, privately owned assets are invested to obtain a return, and these assets flow inexorably to investments appearing to offer the best risk-adjusted returns. An investment offering a less-than-competitive, risk-adjusted return will not attract capital.

The common theme of the three studies is the effort of the government, in the eight issue areas and elsewhere, to chip away at, to limit, and to lower the risk-adjusted return allowed on private assets invested in defense industry, hoping to lower weapon acquisition costs. If these actions combine to force the aggregate risk-adjusted return on defense work below the competitive range, as some argue is already the case, the result *must* be the flight of capital, new and replacement, from the defense industry—surely an intolerable prospect for national security.

Copies of the studies discussed in this article may be obtained as follows:

—FEI Report: Financial Executives Institute, Washington Office, 1100 Seventeenth Street, N.W., Washington, D.C. 20036. 67.

—DIAG Report: Subcommittee on Defense Industry and Technology, Senate Committee on Armed Services, United States Senate, Washington, D.C. 20510. 68.

—MAC Report: National Security Industrial Association, National Headquarters, 1015 15th Street, N.W., Suite 901, Washington D.C. 20005. 69.

*The MAC Group is a consulting firm formed by a group of Harvard Business School professors.

Doctor Waelchli is a Professor of management, Business Management Department, at the Defense Systems Management College and a member of the DSMC Center for Acquisition Management Policy.

PROGRAM MANAGER'S GUIDE
FOR MONITORING CONTRACTOR OVERHEAD/INDIRECT COST

Ronald L. Baker

In December 1984, the Deputy Secretary of Defense issued a memorandum, "Initiative to Reduce Overhead." The memorandum identified ten principles of overhead cost control and was forwarded to chief executive officers of major defense firms seeking their help in controlling overhead costs. These principles gave government and industry objectives to monitor and manage overhead cost and were intended to set the direction and tone of the Department of Defense (DOD) commitment to overhead reduction. The ten principles of overhead cost control appeared in the March-April 1985 issue of *Program Manager*.

Since then, government and industry have done much to focus on reducing overhead/indirect costs on weapon systems. Developing improved overhead cost-reduction procedures is increasingly important because overhead is a major percentage of total contractual costs. Increased mechanization produces an increasing overhead percentage in the absence of strong control measure. A major reason for this increase is the requirement for highly skilled personnel to maintain computer hardware and software. Programs such as the Industrial Modernization Incentives Program (IMIP) reduce direct cost elements through capital investment. Without overhead reduction, portions of the potential total cost reduction will be lost.

Through the IMIP, the DOD provides contractors incentives to invest in capital improvements. This improves productivity and reduces costs. "Productivity Improvements to Reduce Contractor Overhead," a research paper completed in April 1987 by an Air Force Reserve group assigned to the Aeronautical Systems Division, indicated many techniques and concepts used in the IMIP program to identify changes and provide incentives to contractors have direct application to overhead reductions. Indirect or overhead costs are always significant or dominant in the cost of systems acquisition. These costs are allocated to all programs in a contractor's plant. This makes it difficult for program managers to apply control mechanisms. This multiple-program aspect of overhead is similar to contractors' capital facilities and equipment which normally benefit their programs. Direct program costs and indirect overhead costs share most expenses; i.e., labor, equipment, and materials. As such, investments could reduce direct and overhead costs and improve productivity.

Currently, overhead cost is controlled by the Forward Pricing Rate Agreement (FPRA). This utilizes provisional billing rates based on historical experience and estimates of business volume during the period involved. Final rates are negotiated after the end of the period and an audit of actual overhead costs. The FPRA approach has been in place for the past 15 years. One study states it "emphasizes three factors: the concept of cost avoidance, the Air Force assumption of responsibility for overhead management at plants for which it has responsibility, and a larger role for the on-site plant office in the overhead process." Cost avoidance should focus efforts on *future* cost reduction. Also, the Air Force, rather than the Defense Contract Audit Agency, monitors and settles overhead matters and is involved in the on-site Air Force office in surveillance and settlement activities.

The current Air Force system for overhead control uses FPRAs primarily, but includes the Monitoring Overhead through Discrete Evaluations (MODE) computer program; overhead should-cost evaluations; the Air Force indirect cost monitoring team consisting of an overhead monitor, an industrial engineer and an auditor; and the proposed use of traditional fee-sharing to control overhead expenditures. A recent approach is the use of Memoranda of Understanding (MOU) between the Air Force and contractors covering some voluntary measures that the contractors will take to reduce overhead.

Recently, the Defense Systems Management College developed the *Program Managers Guide for Monitoring Contractor Overhead/Indirect Cost*. This was written for the non-financial manager and provides a succinct tool for program managers and acquisition staffs to use in their oversight roles of weapon systems overhead costs. The guide includes overhead cost topics such as: the definition of overhead and indirect cost, creation of indirect cost pools, compliance with cost accounting standards, and explanation of procedures and tools used by the indirect cost team in monitoring contractors. There is no single source of literature available to provide acquisition personnel with a complete overview of indirect/overhead costs. The guide provides this overview and gives the program manager a greater understanding on the role and responsibility of monitoring program costs.

This guide will be available early in FY 89.

Mr. Baker, formerly a member of the Research Staff at the Defense Systems Management College, is now Deputy Program Manager for Training Systems, U.S. Marine Corps Research, Development and Acquisition Command, Quantico, Va.

PROCUREMENT REFORM INITIATIVES: COMPETITION

The Honorable Bill Nichols

Congressman Bill Nichols (D., Ala.)

I spoke to an Army group of acquisition leaders in July 1985, on the importance attached by the Congress to the Competition in Contracting Act (CICA). Before addressing more recent procurement reform initiatives, a word about competition.

In 1982, there were skeptics within the Department of Defense thinking competition would cause a host of horrors; those outside the Department believed nothing could stop it from buying from favorite suppliers. So far, time has proved the skeptics wrong.

Procurement actions awarded competitively have increased dramatically, from 48 percent in 1983 to 88 percent in 1987. The dollar value of competitively awarded contracts increased from 41.2 percent in 1983 to 58.8 percent in 1987.

The vigil is not over. It is too soon to say everyone within the Department is responsible for acquisition—contracting officer, program manager, and those involved in requirements generation—necessarily believe competition is a good thing. That change in mind-set won't happen overnight. It won't occur unless the drive for competition is done in a sensible manner.

As I said in 1985, soon after the Competition in Contracting Act passed, the Congress is looking for a process in which people act as if money being spent is their own—and that they use common sense when spending that money. That means the person consider all available information and make a sound business judgment.

One important aspect of sound business judgment is whether to utilize competition. Then, we believed people were not looking at benefits of competition, like reduced price, better quality, etc., because the system fostered an environment penalizing one for pursuing competition. It was safer and less time-consuming to execute a sole-source contract than to go competitive.

By legislating changes in that process, I hope we removed some impediments. We created a presumption that competition made sense. We did not abolish, however, the need to make an informed judgment concerning the best acquisition approach.

The fact is that virtually every procurement is different in some respect. No rule or regulation can be drafted to apply neatly and give the best result in every situation. So, no matter how many rules there are, only you can assess the situation and structure the best acquisition strategy for the government.

We are looking for personal accountability and elimination of unnecessary layers of bureaucracy, not to have a person to point the finger at when things go wrong; rather, to give authority back to the person responsible for making a decision, and to stop second-guessing.

This concern was the genesis for the program executive officer (PEO) concept. Although this concept was conceived by the Packard Commission, the Congress was receptive to the idea because it fit hand-in-glove with another concern of ours—that there is no accountability in the Department of Defense acquisition process. Program managers were changing frequently, and so many people were involved in making programmatic decisions that it was impossible to say any one person was in charge of a program.

By embracing the program executive officer concept we are trying to streamline the process by establishing simple lines of communication and responsibility. We hoped this might

force a reevaluation of the necessity for reviewing organizations. Even if it does not result in a reduction in the bureaucracy, however, we hope it will force people to make inputs to the decision-maker at the start, rather than second-guessing decisions already made.

Some said various procurement reform measures take away authority of the contracting officer or program manager. I agree in some cases, when the Congress believed decisions being made were not appropriate, it has acted to limit that exercise of judgment. A good example is Navy fixed-price contracts for research and development. We understood what they were trying to accomplish but we did not believe using fixed-price contracts was the appropriate way to meet the objective. When this policy continued despite objections, the Congress adopted a prohibition in the defense segment of the continuing resolution to use fixed-price contracts for research and development.

While the Congress has legislated many prohibitions on some acquisition activities, these prohibitions are, in reality, simple boundaries on the range of options available to the acquistion manager; prohibitions are in no way, shape, or form intended as a substitute for ability to examine facts and circumstances and judge what is the best action. If you examine statements made by members of the Congress in the last few years, it should become apparent the consistent underlying theme is that people cannot and should not hide behind rules and regulations. The system cannot work otherwise. We need to make decisions based on unique circumstances of each procurement. The system relies on each person making the best decisions about each aspect of the acquisition process.

> No rule or regulation can be drafted to apply neatly and give the best result in every situation.

The Congress knows the system is as good as the people who run it; thus, their concern about quality of the work force. In the last few years, there have been proposals to improve the lot of acquisition personnel. While I don't necessarily always agree with the approach taken, you should know what these proposals entail.

They include proposals to establish an elite acquisition corps, establish minimum educational criteria for acquisition personnel and, finally, eliminate established pay grades in favor of a system recognizing outstanding work with bonuses and merit pay.

The Congress emphasized educational opportunities for government acquisition personnel. In 1987, we mandated that Department of Defense reassess acquisition training programs conducted by the military services and the Defense Logistics Agency. We established a requirement that training of acquisition personnel at least be coordinated within the Department of Defense.

> The Congress knows the system is as good as the people who run it; thus, their concern about quality of the work force.

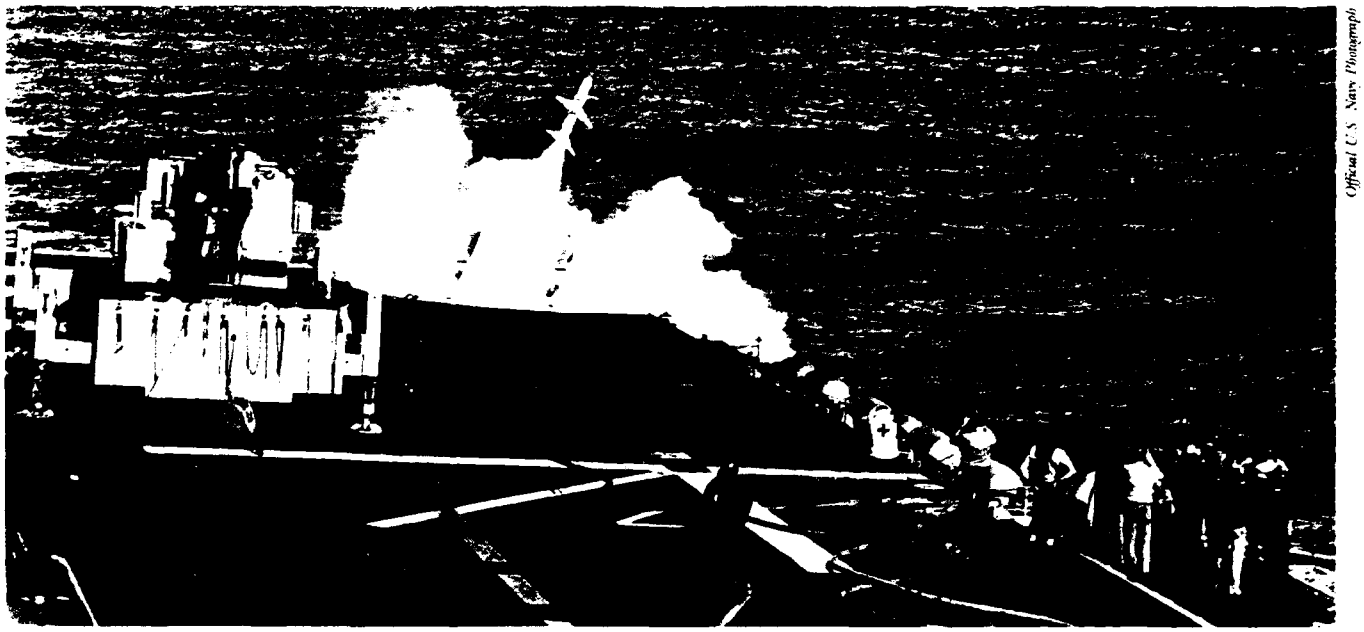
Some proposals are controversial. We may not have all the answers, but we are concerned.

I hope you know the Congress recognizes there must be some judgment involved in the acquisition process. While we put boundaries on exercising that judgment, we have attempted to make sure you retain the ability to make necessary decisions. Remember what an old Texan once said: "There's nothing in the middle of the road but yellow stripes and dead armadillos."

This is adapted from remarks made at the Defense Systems Management College by The Honorable Bill Nichols, Democratic Congressman from Alabama, to the Army Competition Leaders Conference.

USE OF PRODUCTION RATE AS INDEPENDENT VARIABLES IN COST MODELS

Dr. Michael N. Beltramo



Official U.S. Navy Photograph

An AIM-7 Sea Sparrow Missile is fired from the aft Basic Point Defense Missile System Launcher on the Amphibious Assault Ship USS Iwo Jima, LPH-2.

There is a growing trend in cost analysis to incorporate production rate variables into cost estimating relationships intended for general application. An article in *The Journal of Cost Analysis* (Camm, Gulledge and Womer, "Production Rate and Contractor Behavior," Vol. 5, No. 1) identifies key studies related to the effect of production rate on cost and provides an excellent quantitative analysis. These notes were written from a different perspective; specifically, hypotheses should not be accepted unless they can withstand theoretical and logical scrutiny *as well as* empirical validation.

The following comments suggest logical hurdles that need to be cleared to accept a model that relates production cost to production rate for similar items produced in different environments.

A conceptual overview of production rate and its presumed effect on production cost gets to the heart of the matter. There is general agreement that producing at an optimal rate results in the lowest cost, all else being equal. This allows available capital and labor, direct and indirect, to be fully utilized. At a lower rate, surplus is charged to the smaller output. At a higher rate, inefficient substitutions (e.g., added labor instead of additional equipment, or inadequate maintenance) are made and increase cost.

There are many possible ways to produce a particular item by making capital/labor and raw material/purchased part tradeoffs, for example. Each firm has unique characteristics driving its production processes. In particular, two general types of plants exist in defense industries. One is product oriented where each output has a dedicated production line, including labor, tooling, and capital equipment. In many cases, a product-oriented plant produces a single item. The other is process oriented where a particular function like circuit-board production or testing is performed for end-items. The following assumptions may be made about optimal production rates and plant types:

—A discrete, optimal production rate may exist for a specific item in a product-oriented plant.

—Two product-oriented plants may have very different optimal-production rates for the same product depending upon how they are facilitized, staffed, and tooled.

—An optimal production rate for a process-oriented plant depends on total through-put; that is, a decrease in production rate for one item may be compensated for by an increase for another with no decline in efficiency (i.e., increase in cost).

TABLE 1. SPARROW AIM-7F BUY VS. PRODUCTION QUANTITIES

FY	RAYTHEON		GENERAL DYNAMICS	
	Buy	Production	Buy	Production
1972	100*	—	—	—
1973/74	225	24	15*	—
1975	600	167	70	—
1976	880	332	210	—
1977	1110	925	210	70
1978	1400	1086	750	395
1979	900	1077	1310	391
1980	1144	1000	300	1027
1981	—	722	—	961
1982	—	881	—	—
1983	—	41	—	—
Total	6359	6255**	2865	2844**

*Not included in production quantities. Note: First lots may be development units.

**For Raytheon, the difference between the total buy and the total production quantity is because the production quantity does not include the first buy of 100 units and the FY 73/74 and FY78 production data supplied by NAVAIR were each missing two units.

**For General Dynamics, the difference between the total buy and the total production quantity is because the production quantity does not include the first buy of 15 units and the FY78 and FY80 production data supplied by NAVAIR were in net error of minus six units.

The typical production cost vs. production rate relationship is characterized by a U-shaped curve. Therefore, a given rate may be too low for one plant to operate efficiently but too high for another. This is different than learning-curve theory which holds that "more is cheaper." Thus, the idea of correlating quantities by time period with cost for similar but not identical items produced in a variety of environments is difficult to fathom in the absence of other information.

Even if the serious logical issues are ignored, there are practical problems related to calculating the effect of production rate on cost. The first problem is that rate data are not reported routinely. Therefore, annual procurement quantities are commonly used as a proxy for production rate because they are easier to obtain than data related to annual deliveries. Even deliveries may misrepresent when production actually occurred as prime contractor work may be completed but not delivered pending readiness of the government user to accept it or prime contractor labor could be essentially complete with delivery delayed pending the integration of government furnished equipment; e.g., missile warheads or aircraft engines.

The two may vary significantly. Consider annual procurement quantities and annual delivery quantities for Sparrow AIM-7F shown in Table 1. Both firms used the time lag between contract award and the beginning of production to achieve a relatively stable production rate. Dramatic rate variances implied by annual procurement quantities that could have increased costs were avoided; therefore, any production rate effects calculated for that program based upon procurement quantities, rather than deliveries, may be more apparent than real.

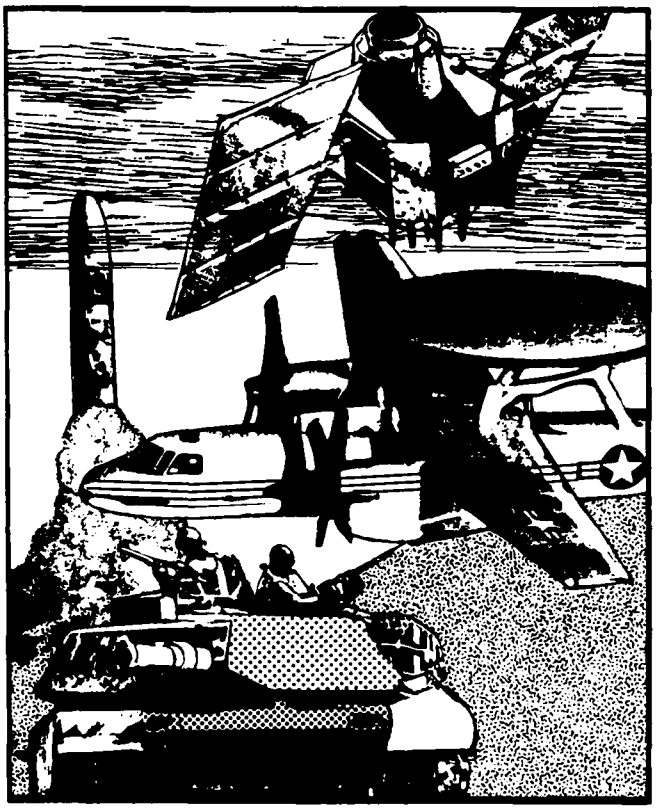
Another problem observed when analysts apply production rate factors is that they do not adjust learning-curve slopes. This causes double counting. Production rate effects are the effect of quantity per time period on cost and learning is the effect of quantity on cost; therefore, learning curves implicitly include production rate effects, although they may be cancelled when they fluctuate significantly during the period covered. The need to adjust learning-curve slopes when applying a rate slope is obvious. An appropriate method for making the adjustment has not been identified.

There is widespread agreement concerning the importance of production rate as a cost driver in the abstract. It is possible to develop cost estimating relationships which include an appropriate production rate variable for individual plants or specific products in a particular plant. It has not been demonstrated that various production rates for similar products in different production environments have, or should have, the same effect on cost.

The author is president of Beltramo and Associates, a defense acquisition consulting firm in Los Angeles.

TOTAL QUALITY MANAGEMENT: A DOD EXAMPLE

Commander J. C. Boudreaux, USN



Quality management principles are not new in the United States. Walter Shewhart wrote about control of industrial quality as early as 1931. Dr. W. Edwards Deming and Dr. J. M. Juran, two prominent American quality theorists, introduced quality management techniques to Japan in the 1950s. S. V. Feigenbaum, P. B. Crosby and others have translated general theories into practical applications that are changing the corporate outlook of United States industry toward quality management. Although each individual quality theorist has a slightly different emphasis, there are six basic principles to which all adhere.

First, management, not the worker, is responsible for process quality. Management must provide resources and policy decisions to make process changes and facilitate tasks of the work force.

Second, continuous improvement of process quality through control of variability yields productivity improvement. Quality management emphasizes continuous search for a better productivity by improving work methods and reducing rework.

Third, the worker can provide a significant input to process quality control. The operator of a process is in the best position to identify process weaknesses and to offer suggestions for process improvement.

Fourth, quality cannot be inspected into a product. Inspection identifies the defective product but cannot eliminate cause of the defect.

Fifth, statistical and graphic techniques support the quality management decision-making process. Simple graphs define process capability and can be used by the manager to make decisions concerning changes to the process.

Sixth, all levels of the organization must be trained to understand the company's quality philosophy and to implement that policy. Every level of an organization must have the common mission and common language with which to communicate.

Resurgence of these principles has been stimulated by American industry's reaction to the Japanese competition in international markets. United States industry has begun using these total quality management principles to regain the competitive position in the world market. At least one group of government agencies is following industry's lead.

A recent example of total quality management illustrates applicability of these quality principles to production and administrative areas within Department of Defense organizations. The Naval Aviation Depot (NADEP), North Island, San Diego, Calif., is a Department of Defense organization making a long-term commitment to total quality management.

The NADEP is a complex industrial facility performing depot-level maintenance, overhauling and repairing engines and components from Naval aircraft, and performing similar maintenance on support systems related to naval aviation. The Navy operates six NADEPs at Norfolk, Va., Cherry Point, N.C., Jacksonville, Fla., Pensacola, Fla., Alameda, Calif., and San Diego, Calif. The six NADEPs represent a complex mix of products and processes.

One early effort to improve quality control was an artisan certification program managed by the Quality Assurance Department at each NADEP. Previous programs included quality circles, quality goals, slogan programs, quality reporting and auditing activities. These programs contributed to quality awareness but fell short of providing coordinated, continuing improvement in the overall quality of product and in the efficiency of NADEP operations.

By instituting quality management techniques, NADEP at North Island focused on increasing productivity and providing a product to meet customer expectations. The NADEP emphasized long-term management commitment to change corporate attitude. Previously, management approached change with fear and uncertainty. After total quality management practices were implemented, management actively sought and encouraged change.

Using quality management, the organization was trained at all levels to think in terms of process quality. The work force was taught to use simple graphical methods of statistical process control to make statistically based decisions affecting their processes. The new attitude included mutual action among departments of the organization for process quality. Customer requirements were used to define good quality and the definition of customer was extended to include the user of products within and outside the organization. One management role in quality management was to assist each organization element to recognize internal and external customers and requirements.

The quality management program at NADEP in North Island evolved slowly during 4 years. Initial activity included exchanging books and discussing current industrial trends in quality management. Interest grew and, after visits to local industry, a small group of managers started an informal training program based on seminars of Dr. Deming. Between 1980-84 the awareness and training effort exposed 200 upper and middle managers to quality management ideas. A network developed to obtain and distribute literature concerning quality activity occurring in private industry. Dr. Deming provided personal support to the network in the form of appearances at North Island to discuss quality theory.

In 1984, the commanding officer of NADEP, North Island, commissioned a demonstration effort in the Manufacturing Division of the facility. The demonstration attempted to establish implementation procedures and apply quality management techniques to the working environment. Specific objective was to establish the customer-to-supplier relationship between the grinding and plating shops to reduce defects and reduce cost of correcting defects. By identifying and breaking down communication barriers between shops, the NADEP management started a continuous cycle of improvement in the processes supported by the two shops. The resulting cooperation between the shops was directed at building quality into the processes and eliminating the requirement for extensive inspection for defects. The initial training in group decision-making established common methods to examine the process. Communications were sustained at regular meetings between the shops.

In addition to working-level meetings, shop supervisors met weekly with the next level of supervision. This management team established priorities and assigned resources to working-level activities. This quality process was developed using guidelines from Kaoru Ishakawa's *Guide to Quality Control* but was uniquely adapted by the Naval Aviation Depot to its organization.

Any quality improvement system is a process and evolves by using techniques of quality management. The NADEP quality improvement system was systematically changed over a period of years. This dynamic management effort was successful in transforming the daily business routine from conflict to teamwork. In one specific case, combined efforts of the plating and grinding teams reduced the defect rate on a H-46 helicopter blade fold pin rework from 70 to 3 percent. Detailed techniques used to identify and eliminate contributors to the defect rate were part of the statistical process control methods of quality management.

While the NADEP demonstration effort continued in selected shops, upper management was taking plant-wide initiatives, using lessons learned from the demonstration. From the demonstration effort, management realized that principles of process quality management applied to service and support processes as well as to production line processes. Concepts were successfully applied to such diverse areas as long-range planning activities and administration of individual travel procedures.

The customer-supplier emphasis for service-oriented efforts were similar to the production effort. Each management group asked initial questions: What is our product? Who is our customer? Who are our suppliers?

With answers to these questions the management used basic process quality management techniques to measure performance of the process that they managed. Management identified elements of the process they used to transform suppliers' inputs into the output for their customers. Each group identified and prioritized opportunities to improve their process and to enhance the quality of their ultimate product.

Success of the improvement initially depended on energetic communication. Communicating with suppliers ensured input specifications were met; communicating with process operators ensured the quality definitions support the ultimate product; and communicating with the customer ensured

the product would meet the customer's expectations. Functions of "continuous process audit" and "control point sampling" were carried out continuously by management. Process audit activity was initiated by management using information from the customer or from workers that indicated an opportunity to improve the system. Control point sampling allowed management to monitor process fluctuations using measurements established and collected by the process operators at the working level.

Once the process control system was in place, management continuously asked questions: How can we reduce variability in our product quality by reducing variability in our control points? Have conditions of our supplier's inputs changed? Have customers' requirements changed? Translating the answers to these questions into action brought about systematic changes to improve process quality.

Principles demonstrated at North Island are applicable everywhere in the Department of Defense. By using this process control system, management can more closely control quality of output and avoid the quick-reaction crisis that leads to inefficiency. Advantages gained through quality control ultimately result in increased productivity and reduced cost through elimination of process inefficiencies. The process control system applies regardless of the nature of the product. The concepts apply to all systems in the Department of Defense whether the product is hardware, software, paperwork or services. Ideas of customer-to-supplier interaction have tremendous potential for the Department of Defense.

Just as United States industry is being driven by competitive pressure to reexamine management techniques, the Department of Defense is being driven by budget reduction to improve productivity and increase cost effectiveness. The Department of Defense has taken specific actions to address specific productivity and cost-effectiveness symptoms.

Total quality management represents a proved method that can be applied in all Department of Defense organizations to increase productivity and to reduce cost. Budget pressures demand action. Inaction will ultimately degrade the effectiveness of our defense system.

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